SCIENCE

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CONTENTS:

MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

*THE HIGHEST AIM OF THE PHYSICIST.**

GENTLEMEN AND FELLOW PHYSICISTS OF AMERICA: We meet to day on an occasion which marks an epoch in the history of physics in America; may the future show that it also marks an epoch in the history of the science which this Society is organized to cultivate! For we meet here in the interest of a science which above all sciences deals with the foundation of the Universe, with the constitution of matter from which everything in the Universe is made and with the ether of space by which alone the various portions of matter forming the Universe affect each other even at such distances as we may never expect to traverse, whatever the progress of our science in the future.

We, who have devoted our lives to the solution of problems connected with physics, now meet together to help each other and to forward the interests of the subject which we love. A subject which appeals most strongly to the better instincts of our nature and the problems of which tax our minds to the limit of their capacity and suggest the grandest and noblest ideas of which they are capable.

In a country where the doctrine of the equal rights of man has been distorted to mean the equality of man in other respects,

* Address delivered to the Physical Society of America by the President, at its meeting in New York, October 28, 1899.

we form a small and unique body of men, a new variety of the human race as one of our greatest scientists calls it, whose views of what constitutes the greatest achievement in life are very different from those around us. In this respect we form an aristocracy, not of wealth, not of pedigree, but of intellect and of ideals, holding him in the highest respect who adds the most to our knowledge or who strives after it as the highest good.

Thus we meet together for mutual sympathy and the interchange of knowledge, and may we do so ever with appreciation of the benefits to ourselves and possibly to our science. Above all, let us cultivate the idea of the dignity of our pursuit so that this feeling may sustain us in the midst of a world which gives its highest praise, not to the investigation in the pure etherial physics which our Society is formed to cultivate, but to one who uses it for satisfying the physical rather than the intellectual needs of mankind. He who makes two blades of grass grow where one grew before is the benefactor of mankind; but he who obscurely worked to find the laws of such growth is the intellectual superior as well as the greater benefactor of the two.

How stands our country, then, in this respect? My answer must still be, now, as it was fifteen years ago, that much of the intellect of the country is still wasted in the pursuit of so-called practical science which ministers to our physical needs and but little thought and money is given to the grander portion of the subject which appeals to our intellect alone. But your presence here gives evidence that such a condition is not to last forever.

Even in the past we have a few names whom scientists throughout the world delight to honor. Franklin, who almost revolutionized the science of electricity by a few simple but profound experiments. Count Rumford, whose experiments almost demonstrated the nature of heat. Henry, who might have done much for the progress of physics had he published more fully the results of his investigations. Mayer, whose simple and ingenious experiments have been a source of pleasure and profit to many. This is the meager list of those whom death allows me to speak of and who have earned mention here by doing something for the progress of our science. And yet the record has been searched for more than a hundred years. How different had I started to record those who have made useful and beneficial inventions!

But I know, when I look in the faces of those before me, where the eager intellect and high purpose sit enthroned on bodies possessing the vigor and strength of youth, that the writer of a hundred years hence can no longer throw such a reproach upon our country. Nor can we blame those who have gone before us. The progress of every science shows us the condition of its growth. Very few persons, if isolated in a semi-civilized land, have either the desire or the opportunity of pursuing the higher branches of science. Even if they should be able to do so, their influence on their science depends upon what they publish and make known to the world. A hermit philosopher we can imagine might make many useful discoveries. Yet, if he keeps them to himself, he can never claim to have benefited the world in any degree. His unpublished results are his private gain, but the world is no better off until he has made them known in language strong enough to call attention to them and to convince the world of their truth. Thus, to encourage the growth of any science, the best thing we can do is to meet together in its interest, to discuss its problems, to criticize each other's work and, best of all, to provide means by which the better portion of it may be made known to the world. Furthermore, let us encourage discrimination in our thoughts

and work. Let us recognize the eras when great thoughts have been introduced into our subject and let us honor the great men who introduced and proved them correct. Let us forever reject such foolish ideas as the equality of mankind and carefully give the greater credit to the greater man. So, in choosing the subjects for our investigation, let us, if possible, work upon those subjects which will finally give us an advanced knowledge of some great subject. I am aware that we cannot always do this; our ideas will often flow in side channels; but, with the great problems of the Universe before us, we may sometime be able to do our share toward the greater end.

What is matter; what is gravitation; what is ether and the radiation through it; what is electricity and magnetism; how are these connected together and what is their relation to heat? These are the greater problems of the universe. But many infinitely smaller problems we must attack and solve before we can even guess at the solution of the greater ones.

In our attitude toward these greater problems how do we stand and what is the foundation of our knowledge?

Newton and the great array of astronomers who have succeeded him have proved that, within planetary distances, matter attracts all others with a force varying inversely as the square of the distance. But what sort of proof have we of this law? It is derived from astronomical observations on the planetary orbits. It agrees very well within these immense spaces; but where is the evidence that the law holds for smaller distances? We measure the lunar distance and the size of the earth and compare the force at that distance with the force of gravitation on the earth's surface. But to do this we must compare the matter in the earth with that in the sun. This we can only do by *assuming* the law to be proved. Again, in descending from the earth's gravitation to that of two small bodies, as in the Cavendish experiment, we *assume* the law to hold and deduce the mass of the earth in terms of our unit of mass. Hence, when we say that the mass of the earth is $5\frac{1}{2}$ times that of an equal volume of water we *assume* the law of gravitation to be that of Newton. Thus a proof of the law from planetary down to terrestrial distances is physically impossible.

Again, that portion of the law which says that gravitational attraction is proportional to the quantity of matter, which is the same as saying that the attraction of one body by another is not affected by the presence of a third, the feeble proof that we give by weighing bodies in a balance in different positions with respect to each other cannot be accepted on a larger scale. When we can tear the sun into two portions and prove that either of the two halves attracts half as much as the whole, then we shall have a proof worth mentioning.

Then as to the relation of gravitation and time what can we say? Can we for a moment suppose that two bodies moving through space with great velocities have their gravitation unaltered? I think not. Neither can we accept Laplace's proof that the force of gravitation acts instantaneously through space, for we can readily imagine some compensating features unthought of by Laplace.

How little we know then of this law which has been under observation for two hundred years!

Then as to matter itself how have our views changed and how are they constantly changing. The round hard atom of Newton which God alone could break into pieces has become a molecule composed of many atoms, and each of these smaller atoms has become so elastic that after vibrating 100,000 times its amplitude of vibration is scarcely diminished. It has become so complicated that it can vibrate

with as many thousand notes. We cover the atom with patches of electricity here and there and make of it a system compared with which the planetary system, nay the universe itself, is simplicity. Nay more: some of us even claim the power, which Newton attributed to God alone, of breaking the atom into smaller pieces whose size is left to the imagination. Where, then, is that person who ignorantly sneers at the study of matter as a material and gross study? Where, again, is that man with gifts so God-like and mind so elevated that he can attack and solve its problem?

To all matter we attribute two properties, gravitation and inertia. Without these two matter cannot exist. The greatest of the natural laws states that the power of gravitational attraction is proportional to the mass of the body. This law of Newton, almost neglected in the thoughts of physicists, undoubtedly has vast import of the very deepest meaning. Shall it mean that all matter is finally constructed of uniform and similar primordial atoms or can we find some other explanation?

That the molecules of matter are not round, we know from the facts of crystallography and the action of matter in rotating the plane of polarization of light.

That portions of the molecules and even of the atoms are electrically charged, we know from electrolysis, the action of gases in a vacuum tube and from the Zeeman effect.

That some of them act like little magnets, we know from the magnetic action of iron, nickel and cobalt.

That they are elastic, the spectrum shows, and that the vibrating portion carries the electrified charge with it is shown by the Zeeman effect.

Here, then, we have made quite a start in our problem: but how far are we from the complete solution? How can we imagine the material of which ordinary or primordial atoms are made, dealing as we do only with aggregation of atoms alone? Forever beyond our sight, vibrating an almost infinite number of times in a second, moving hither and yon with restless energy at all temperatures beyond the absolute zero of temperature, it is certainly a wonderful feat of human reason and imagination that we know as much as we do at present. Encouraged by these results, let us not linger too long in their contemplation but press forward to the new discoveries which await us in the future.

Then as to electricity, the subtile spirit of the amber, the demon who reached out his gluttonous arms to draw in the light bodies within his reach, the fluid which could run through metals with the greatest ease but could be stopped by a frail piece of glass! Where is it now? Vanished, thrown on the waste heap of our discarded theories to be replaced by a far nobler and exalted one of action in the ether of space.

And so we are brought to consider that other great entity—the ether: filling all space without limit, we imagine the ether to be the only means by which two portions of matter distant from each other can have any mutual action. By its means we imagine every atom in the universe to be bound to every other atom by the force of gravitation and often by the force of magnetic and electric action, and we conceive that it alone conveys the vibratory motion of each atom or molecule out into space to be ever lost in endless radiation, passing out into infinite space or absorbed by some other atoms which happen to be in its path. By it all electromagnetic energy is conveyed from the feeble attraction of the rubbed amber through the many thousand horsepower conveyed by the electric wires from Niagara to the mighty rush of energy always flowing from the Sun in a flood of radiation. Actions feeble and actions mighty from inter-

molecular distances through interplanetary and interstellar distances until we reach the mighty distances which bound the Universe—all have their being in this wondrous ether.

And yet, however wonderful it may be, its laws are far more simple than those of matter. Every wave in it, whatever its length or intensity, proceeds onwards in it according to well known laws, all with the same speed, unaltered in direction from its source in electrified matter, to the confines of the Universe unimpaired in energy unless it is disturbed by the presence of matter. However the waves may cross each other, each proceeds by itself without interference with the others.

So with regard to gravitation, we have no evidence that the presence of a third body affects the mutual attraction of two other bodies, or that the presence of a third quantity of electricity affects the mutual attraction of two other quantities. The same for magnetism.

For this reason the laws of gravitation and of electric and magnetic action including radiation are the simplest of all laws when we confine them to a so-called vacuum, but become more and more complicated when we treat of them in space containing matter.

Subject the ether to immense electrostatic, magnetic or gravitational forces and we find absolutely no signs of its breaking down or even of change of properties. Set it into vibration by means of an intensely hot body like the sun and it conveys many thousand horse-power for each square foot of surface as quietly and with apparently unchanged laws as if it were conveying the energy of a tallow dip.

Again, subject a millimeter of ether to the stress of many thousand, nay even a million, volts and yet we see no signs of breaking down.

Hence the properties of the ether are of ideal simplicity and lead to the simplest of natural laws. All forces which act at a distance, always obey the law of the inverse square of the distance, and we have also the attraction of any number of parts placed near each other equal to the arithmetical sum of the attractions when those parts are separated. So also the simpler law of etherial waves which has been mentioned above.

At the present time, through the labors of Maxwell supplemented by those of Hertz and others, we have arrived at the great generalization that all wave disturbances in the ether are electromagnetic in their nature. We know of little or no etherial disturbance which can be set up by the motion of matter alone: the matter must be electrified in order to have sufficient hold on the ether to communicate its motion to the ether. The Zeeman effect even shows this to be the case where molecules are concerned and when the period of vibration is immensely great. Indeed the experiment on the magnetic action of electric convection shows the same thing. By electrifying a disc in motion it appears as if the disc holds fast to the ether and drags it with it, thus setting up the peculiar etherial motion known as magnetism.

Have we not another case of a similar nature when a huge gravitational mass like that of the earth revolves on its axis? Has not matter a feeble hold on the ether sufficient to produce the earth's magnetism?

But the experiment of Lodge to detect such an action apparently showed that it must be very feeble. Might not his experiment have succeeded had he used an electrical revolving disc?

To detect something dependent on the relative motion of the ether and matter has been and is the great desire of physicists. But we always find that, with one possible exception, there is always some compensating feature which renders our efforts use-

less. This one experiment is the aberration of light, but even here Stokes has shown that it may be explained in either of two ways: first, that the earth moves through the ether of space without disturbing it, and second, if it carries the ether with it by a kind of motion called irrotational. Even here, however, the amount of action probably depends upon *relative* motion of the luminous source to the recipient telescope.

So the principle of Döppler depends also on this relative motion and is independent of the ether.

The result of the experiments of Foucault on the passage of light through moving water can no longer be interpreted as due to the partial movement of the ether with the moving water, an inference due to imperfect theory alone. The experiment of Lodge, who attempted to set the ether in motion by a rapidly rotating disc, showed no such result.

The experiment of Michelson to detect the etherial wind, although carried to the extreme of accuracy, also failed to detect any relative motion of the matter and the ether.

But matter with an electrical charge holds fast to the ether and moves it in the manner required for magnetic action.

When electrified bodies move together through space or with reference to each other we can only follow their mutual actions through very slow and uniform velocities. When they move with velocities comparable with that of light, equal to it or even beyond it, we calculate their mutual actions or action on the ether only by the light of our imagination unguided by experiment. The conclusions of J. J. Thomson, Heaviside and Hertz are all results of the imagination and they all rest upon assumptions more or less reasonable but always assumptions. A mathematical investigation always obeys the law of the conservation of knowledge: we never get out more from it than we put in. The knowledge may be changed in form, it may be clearer and more exactly stated, but the total amount of the knowledge of nature given out by the investigation is the same as we started with. Hence we can never predict the result in the case of velocities beyond our reach, and such calculations as the velocity of the cathode rays from their electromagnetic action has a great element of uncertainty which we should do well to remember.

Indeed, when it comes to exact knowledge, the limits are far more circumscribed.

How is it, then, that we hear physicists and others constantly stating what will happen beyond these limits? Take velocities, for instance, such as that of a material body moving with the velocity of light. There is no known process by which such a velocity can be obtained even though the body fell from an infinite distance upon the largest aggregation of matter in the Universe. If we electrify it, as in the cathode rays, its properties are so changed that the matter properties are completely masked by the electromagnetic.

It is a common error which young physicists are apt to fall into to obtain a law, a curve or a mathematical expression for given experimental limits and then to apply it to points outside those limits. This is sometimes called extrapolation. Such a process, unless carefully guarded, ceases to be a reasoning process and becomes one of pure imagination specially liable to error when the distance is too great.

But it is not my purpose to enter into detail. What I have given suffices to show how little we know of the profounder questions involved in our subject.

It is a curious fact that, having minds tending to the infinite, with imaginations unlimited by time and space, the limits of our exact knowledge are very small indeed.

In time we are limited by a few hundred or possibly thousand years: indeed the limit in our science is far less than the smaller of these periods. In space we have exact knowledge limited to portions of our earth's surface and a mile or so below the surface, together with what little we can learn from looking through powerful telescopes into the space beyond. In temperature our knowledge extends from near the absolute zero to that of the sun but exact knowledge is far more limited. In pressures we go from the Crookes vacuum still containing myriads of flying atoms to pressures limited by the strength of steel but still very minute compared with the pressures at the center of the earth and sun, where the hardest steel would flow like the most limpid water. In velocities we are limited to a few miles per second. In forces to possibly 100 tons to the square inch. In mechanical rotations to a few hundred times per second.

All the facts which we have considered, the liability to error in whatever direction we go, the infirmity of our minds in their reasoning power, the fallibility of witnesses and experimenters, lead the scientist to be specially sceptical with reference to any statement made to him or any so-called knowledge which may be brought to his attention. The facts and theories of our science are so much more certain than those of history, of the testimony of ordinary people on which the facts of ordinary history or of legal evidence rest, or of the value of medicines to which we trust when we are ill, indeed to the whole fabric of supposed truth by which an ordinary person guides his belief and the actions of his life, that it may seem ominous and strange if what I have said of the imperfections of the knowledge of physics is correct. How shall we regulate our minds with respect to it: there is only one way that I know of and that is to avoid the discontinuity of the ordinary, indeed the so-called cultivated legal mind. There is no such thing as absolute truth and absolute falsehood. The scientific mind should never recognize the perfect truth or the perfect falsehood of any supposed theory or observation. It should carefully weigh the chances of truth and error and grade each in its proper position along the line joining absolute truth and absolute error.

The ordinary crude mind has only two compartments, one for truth and one for error; indeed the contents of the two compartments are sadly mixed in most cases: the ideal scientific mind, however, has an infinite number. Each theory or law is in its proper compartment indicating the probability of its truth. As a new fact arrives the scientist changes it from one compartment to another so as, if possible, to always keep it in its proper relation to truth and error. Thus the fluid nature of electricity was once in a compartment near the truth. Faraday's and Maxwell's researches have now caused us to move it to a compartment nearly up to that of absolute error.

So the law of gravitation within planetary distances is far toward absolute truth, but may still need amending before it is advanced farther in that direction.

The ideal scientific mind, therefore, must always be held in a state of balance which the slightest new evidence may change in one direction or another. It is in a constant state of skepticism, knowing full well that nothing is certain. It is above all an agnostic with respect to all facts and theories of science as well as to all other so-called beliefs and theories.

Yet it would be folly to reason from this that we need not guide our life according to the approach to knowledge that we possess. Nature is inexorable; it punishes the child who unknowingly steps off a precipice quite as severely as the grown scientist who steps over, with full knowledge of all the

laws of falling bodies and the chances of their being correct. Both fall to the bottom and in their fall obey the gravitational laws of inorganic matter, slightly modified by the muscular contortions of the falling object but not in any degree changed by the previous belief of the person. Natural laws there probably are, rigid and unchanging ones at that. Understand them and they are beneficent: we can use them for our purposes and make them the slaves of our desires. Misunderstand them and they are monsters who may grind us to powder or crush us in the dust. Nothing is asked of us as to our belief: they act unswervingly and we must understand them or suffer the consequences. Our only course, then, is to act according to the chances of our knowing the right laws. If we act correctly, right; if we act incorrectly, we suffer. If we are ignorant we die. What greater fool, then, than he who states that belief is of no consequence provided it is sincere.

An only child, a beloved wife, lies on a bed of illness. The physician says that the disease is mortal; a minute plant called a microbe has obtained entrance into the body and is growing at the expense of its tissues, forming deadly poisons in the blood or destroying some vital organ. The physician looks on without being able to do anything. Daily he comes and notes the failing strength of his patient and daily the patient goes downward until he rests in his grave. But why has the physician allowed this? Can we doubt that there is a remedy which shall kill the microbe or neutralize its poison? Why, then, has he not used it? He is employed to cure but has failed. His bill we cheerfully pay because he has done his best and given a chance of cure. The answer is *ignorance*. The remedy is yet unknown. The physician is waiting for others to discover it or perhaps is experimenting in a crude and unscientific manner to find it. Is not the inference correct, then, that the world has been paying the wrong class of men? Would not this ignorance have been dispelled had the proper money been used in the past to dispel it? Such deaths some people consider an act of God. What blasphemy to attribute to God that which is due to our own and our ancestors' selfishness in not founding institutions for medical research in sufficient number and with sufficient means to discover the truth. Such deaths are murder. Thus the present generation suffers for the sins of the past and we die because our ancestors dissipated their wealth in armies and navies, in the foolish pomp and circumstance of society, and neglected to provide us with a knowledge of natural laws. In this sense they were the murderers and robbers of future generations of unborn millions and have made the world a charnel house and place of mourning where peace and happiness might have been. Only their ignorance of what they were doing can be their excuse, but this excuse puts them in the class of boors and savages who act according to selfish desire and not to reason and to the calls of duty. Let the present generation take warning that this reproach be not cast on it, for it cannot plead ignorance in this respect.

This illustration from the department of medicine I have given because it appeals to all. But all the sciences are linked together and must advance in concert. The human body is a chemical and physical problem, and these sciences must advance before we can conquer disease.

But the true lover of physics needs no such spur to his actions. The cure of disease is a very important object and nothing can be nobler than a life devoted to its cure.

The aims of the physicist, however, are in part purely intellectual; he strives to understand the Universe on account of the intellectual pleasure derived from the pursuit, but he is upheld in it by the knowl-

edge that the study of nature's secrets is the ordained method by which the greatest good and happiness shall finally come to the human race.

Where, then, are the greatest laboratories of research in this city, in this country, nay, in the world? We see a few miserable structures here and there occupied by a few starving professors who are nobly striving to do the best with the feeble means at their disposal. But where in the world is the institute of pure research in any department of science with an income of $100,000,000 per year. Where can the discoverer in pure science earn more than the wages of a day laborer or cook? But $100,000,000 per year is but the price of an army or a navy designed to kill other people. Just think of it, that one per cent. of this sum seems to most people too great to save our children and descendants from misery and even death!

But the twentieth century is near—may we not hope for better things before its end? May we not not hope to influence the public in this direction?

Let us go forward, then, with confidence in the dignity of our pursuit. Let us hold our heads high with a pure conscience while we seek the truth, and may the American Physical Society do its share now and in generations yet to come in trying to unravel the great problem of the constitution and laws of the Universe.

HENRY A. ROWLAND.

CRUISE OF THE ALBATROSS.

THE following letter has been received by the U. S. Fish Commission from Professor Alexander Agassiz. It is dated Papeete Harbor, Tahiti Island, September 30, 1899, and gives an account of the voyage of the *Albatross* up to that time.

I arrived at San Francisco on August 20th, and after consulting with Commander Moser we decided to leave on Wednesday, the 23d. Everything shipped from the east had arrived with the exception of the tow nets sent me by Dr. Kramer, and the deep-sea nets kindly ordered for me by Professor Chun of Leipzig. Captain Moser and I decided not to make any soundings nor do any deep-sea work until we had passed beyond the lines of soundings already run by the *Albatross* and *Thetis* between California and the Hawaiian Islands.

In latitude 31° 10′ N., and longitude 125° W., we made our first sounding in 1955 fathoms, about 320 miles from Point Conception, the nearest land. We occupied 26 stations until we reached the northern edge of the plateau from which rise the Marquesas Islands, having run from station No. 1, a distance of 3800 miles, in a straight line.

At station No. 2 the depth had increased to 2368 fathoms, the nearest land, Guadeloupe Island, being about 450 miles, and Point Conception nearly 500 miles distant. The depth gradually increased to 2628, 2740, 2810, 2881, 3003, and 3088 fathoms, the last in lat. 16° 38′ N., long. 130 14′ W., the deepest sounding we obtained thus far in the unexplored part of the Pacific through which we are passing. From that point the depths varied from 2883 to 2690 and 2776, diminishing to 2583, and gradually passing to 2440, 2463, and 2475 fathoms, until off the Marquesas, in lat. 7° 58′ S., long. 139° 08′ W., the depth became 2287 fathoms. It then passed to 1929, 1802, and 1040 fathoms, in lat. 8° 41′ S, long. 139° 46′ W., Nukuhiva Island being about 30 miles distant. Between Nukuhiva and Houa-Houna (Ua-Huka) islands we obtained 830 fathoms, and 5 miles south of Nukuhiva 687 fathoms. When leaving Nukuhiva for the Paumotus we sounded in 1284 fathoms about 9 miles south of that island. These soundings seem to show that this part of the Marquesas rises from a

plateau having a depth of 2000 fathoms, and about 50 miles in width, as at station No. 29 we obtained 1932 fathoms.

Between the Marquesas and the northwestern extremity of the Paumotus we occupied 9 stations, the greatest depth on that line being at station No. 31, in lat. 12° 20′ S., and long. 144° 15′ W. The depths varied between 2451 and 2527 fathoms, and diminished to 1208 fathoms off the west end of Ahii, and then to 706 fathoms when about 16 miles N. E. of Avatoru Pass in Rairoa Island.

We developed to a certain extent the width of the Paumotu group plateau by a line of soundings in continuation of the direction of Avatoru Pass, extending a little less than 9 miles seaward where we obtained a depth of 819 fathoms. Subsequently we ran a similar line normal to the south shore of the lagoon of Rairoa a distance of nearly 12 miles into 897 fathoms.

Between Rairoa and Tikehau, the next island to the westward, we got a depth of 1486 fathoms.

Between Tikehau and Mataiwa 6 soundings were made with a depth of 488 fathoms half a mile from shore, and a greatest depth of 850 fathoms 6½ miles from Tikehau. The slope approaching Mataiwa is steeper than the Tikehau slope.

From Mataiwa to Makatea (Aurora) Island, we made 6 soundings: from 642 fathoms about 2½ miles off shore, to 581 fathoms about 1⅓ miles off the west side of the latter island, the depths passing to 860, 1257, 1762, and the greatest depth being 2267 fathoms; then 2243, and rising more rapidly near Makatea to 851 fathoms.

Between Makatea and Tahiti we made 8 soundings, beginning with 1363 fathoms, 2 miles off the southern end of Makatea, passing to 2238, 2363 (the greatest depth on that line), 2224, 1930, 1585, 775, and finally 867 fathoms off Point Venus.

These make in all 72 soundings up to the present time.

The deep basin developed by our soundings between lat. 24° 30′ N., and lat. 6° 25′ S., varying in depth from nearly 3100 fathoms to a little less than 2500 fathoms, is probably the western extension of a deep basin indicated by two soundings on the charts, to the eastward of our line, in longitudes 125° and 120° W., and latitudes 9° and 11° N., one of over 3100 fathoms, the other of more than 2550 fathoms, showing this part of the Pacific to be of considerable depth, and to form a uniformly deep basin of great extent, continuing westward probably, judging from the soundings, for a long distance.

I would propose, in accordance with the practice adopted for naming such well-defined basins of the ocean, that this large depression of the Central Pacific, extending for nearly 30° of latitude, be named Moser Basin.

The character of the bottom of this basin is most interesting. The haul of the trawl made at station No. 2, lat. 28° 23′ N., long. 126° 57′ W., brought up the bag full of red clay and manganese nodules with sharks' teeth and cetacean ear-bones; and at nearly all our stations we had indications of manganese nodules. At station No. 13, in 2690 fathoms, lat. 9° 57′ N., long. 137° 47′ W., we again obtained a fine trawl haul of manganese nodules and red clay; there must have been at least enough to fill a 40-gallon barrel.

The nodules of our first haul were either slabs from 6 to 18 inches in length and 4 to 6 inches in thickness, or small nodules ranging in size from that of a walnut to a lentil or less; while those brought up at station No. 13 consisted mainly of nodules looking like mammillated cannon balls varying from 4½ to 6 inches in diameter, the largest being 6½ inches. We again brought up manganese nodules at the Equa-

tor in about longitude 138° W., and subsequently—until within sight of Tahiti—we occasionally got manganese nodules.

As had been noticed by Sir John Murray in the *Challenger*, these manganese nodules occur in a part of the Pacific most distant from continental areas. Our experience has been similar to that of the *Challenger*, only I am inclined to think that these nodules range over a far greater area of the Central Pacific than had been supposed, and that this peculiar manganese-nodule bottom characterizes a great portion of the deep parts of the Central Pacific where it cannot be affected by the deposit of globigerina, pteropods, or telluric ooze; in the region characterized also by red-clay deposits. For in the track of the great equatorial currents there occur deposits of globigerina ooze in over 2400 fathoms for a distance of over 300 miles in latitude.

Manganese nodules we found south of the Marquesas also, where in 2700 fathoms we obtained, perhaps, the finest specimens of red clay from any of our soundings. As we approached close to the western Paumotus, and rose upon the plateau from which they rise, globigerina ooze passed gradually to pteropod ooze, then to fine and coarse coral sand. In the channel south of the Paumotus to Tahiti the coral sand passed to volcanic sand mixed with globigerinæ in the deepest parts of the line, and toward Tahiti passed to volcanic mud mixed with globigerinæ, next to fine volcanic sand, and finally, at the last sounding, off Point Venus, to coarse volcanic sand.

We made a few hauls of the trawl on our way, but owing to the great distance we had to steam between San Francisco and the Marquesas (3800 miles) we could not, of course, spend a great deal of time either in trawling or in making tows at intermediate depths. Still the hauls we made with the trawl were most interesting, and confirmed what other deep-sea expeditions have realized: that at great depths, at considerable distances from land and away from any great oceanic current, there is comparatively little animal life to be found. Where manganese nodules were found the hauls were specially poor, a few deep-sea holothurians and ophiurans, and some small actiniæ which had attached themselves to the nodules with a few other invertebrates, seemed to be all that lived at these great depths, 2500 to 2900 fathoms, far away—say from 700 to 1000 miles—from the nearest land.

The bottom temperatures of the deep (Moser) basin varied between 34.6° at 2628 and 2740 fathoms, to 35.2° at 2440 fathoms, and 35° at 2475 fathoms; about 120 miles from the Marquesas. At station No. 23, off the Marquesas, in 1802 fathoms, the temperature was 35.5°.

Owing to the failure of our deep-sea thermometers we were not able to make any satisfactory serial-temperature observations. At station No. 11, lat. 14° 38′ N., long. 136° 44′ W., we obtained: 79° at surface, 78.7° at 50 fathoms, 55.9° at 100 fathoms, 48.9° at 200 fathoms, 44.1° at 300 fathoms, and 38.9° at 700 fathoms. These temperatures are somewhat higher than those obtained by the *Challenger* in similar latitudes on their line to the westward of ours between the Sandwich Islands and Tahiti.

The temperatures of the bottom between the Marquesas and Paumotus were 34.9° at 1932 fathoms, 35° at 2456 fathoms and 2451 fathoms, and 35.1° at 2527 fathoms.

We did not take any bottom temperatures between the Paumotus and Tahiti.

Our deep-sea nets not having reached San Francisco at the time we sailed, we limited our pelagic work to surface hauls, of which we generally made one in the morning and one in the evening, and whenever practicable some hauls with the open tow nets at depths varying between 100 and 350 fathoms. The results of these hauls

were very satisfactory. The collection of surface animals is quite extensive, and many interesting forms were obtained. As regards the deeper hauls, they only confirm what has been my experience on former expeditions: that beyond 300 to 350 fathoms very little animal life is found, and in the belt above 300 fathoms, the greater number of many so-called deep-sea crustaceans and deep-sea fishes were obtained. I may mention that we obtained Pelagothuria at about 100 fathoms from the surface.

We trawled at station No. 10 in 3088 fathoms. Unfortunately the trawl was not successful, and we simply hauled the bag through over 3000 fathoms without bringing up a single deep-sea animal from intermediate depths which we did not obtain quite near the surface—at less than 300 fathoms. I may mention here that the experience of the *Valdivia* shows, from the preliminary reports published by Professor Chun, that no pelagic algæ extend to beyond about 150 fathoms. Although he also states that animal life is found at all depths from the surface to the bottom, yet he states that beyond 800 meters it diminishes *very rapidly*. Professor Chun does not state whether this diminution is more rapid away from land than near continental areas, both of which conditions I had called especial attention to in my preliminary report on the *Albatross* expedition of 1891, while using the Tanner net in the Gulf of California. Mr. George Murray has criticised the action of the Tanner deep-sea net and condemns its results, suggesting that the bottom net had always closed some time after being sent down. I need not now discuss that subject, but will only refer him to the report of the *Albatross*, in which he will find the closed part of the net to have on several occasions brought up (when I expected it to do so) specimens from over 600 fathoms from immediately above the bottom, or samples of the bottom from near 1700 fathoms while attempting to tow immediately above that depth. I ought, in justice to him, to state that I omitted to mention that we secured the loops by twine to the detacher, to insure their dropping only when the messenger reached the detacher, and that the hooks of the detacher were lengthened very considerably above the dimensions figured in my preliminary report on the *Albatross* in 1891. I might add that we made a number of trials near the surface to see the action of the Tanner net under all conditions of position and speed, and I can only assume that Mr. Murray, having no experience, did not handle his net properly, or that it was not properly balanced. I may also add that Captain Tanner used his modified net subsequently in the *Albatross*, while running a line of soundings from San Francisco to Hawaiian Islands, in from 100 to 350 fathoms from the surface, at considerable distances from the islands and the mainland, and also in Alaskan waters, and always with the results we had obtained before. The closed bag, when towing at 100 fathoms below the surface, always brought up a mass of pelagic animals living at about that depth, while when tried at 300–350 fathoms, it brought up little or nothing. There is nothing in Captain Tanner's experience, or mine, to indicate why the net should act well at 100 fathoms and not well at 300 fathoms or more, as suggested by Mr. Murray.

On our way to Tahiti from the Marquesas we stopped a few days to examine the westernmost atolls of the Paumotus. Striking Ahii we made for Rairoa, the largest of the Paumotu group, skirting the northern shore from a point a little west of Tiputa Pass; we entered the lagoon through Avatoru Pass, anchoring off the village. This pass is quite narrow, with a strong current running out the greater part of the time, especially in easterly winds. It varies in

depth between 9 and 10 fathoms, shoaling near the inner entrance to about 3½ fathoms, and deepening again to 6 or 7 fathoms, and gradually passing into 15 to 17 fathoms, which is the average depth of the lagoon from Avatoru Pass to the south or weather shore, a distance of about 13 miles.

We made an examination of the northern side of the lagoon, between Avatoru and Tiputa passes. The lagoon beach of the northern shore is quite steep, and is composed of moderately coarse broken coral sand at the base, and of larger fragments of corals along the upper face, which is about 5 to 6 feet above high-water mark. These coral fragments are derived in part from the corals living on the lagoon face of the northern shore, and in part of fragments broken by the waves from somewhat below the low-water mark. The ledge which underlies the beach crops out at many places on the lagoon side of the northern shore; we traced it also along the shores of Avatoru Pass, and about half way across the narrow land running between Avatoru and Tiputa passes. It crops out also at various points between them in the narrow cuts which divide this part of the northern land of the lagoon into a number of smaller islands. These secondary passes leave exposed the underlying ledge, full of fossil corals. In some cases there is left a clear channel extending across from the lagoon to the northern side through which water flows at high or half tide. In other cases the cuts are silted up with coral sand blown in from the lagoon side. In others, the cut is shut off by a high sand-bank, or a bank composed of broken fragments of corals, leaving access to the water from the northern shore only; and finally the cuts are also shut off on the northern side by sand and broken coral banks, the extension of the north-shore beach leaving a depression which at first is filled with salt water and gradually silted up both from the lagoon side and the sea side, and forms the typical north shore land of the lagoon. This building up of the land of the Paumotu atolls simultaneously both by the accumulation of sand from the lagoon side and the sea face is very characteristic of the atolls of that group. It is a feature which I have not seen so marked in any other coral reef district.

On the lagoon side the slope from the beach is very gradual into 16 and 17 fathoms, and corals appear to flourish on the lagoon slope to 6 or 8 fathoms only, in some cases consisting of Madrepores, Porites, Astræans, and Pocillopores. The corals could be seen over the floor of the Avatoru Passage down to 9 to 10 fathoms; and on the sea face Pocillopores covered the outer edge of the shore platform. This platform is from 200 to 250 feet wide, and was formed by the planing off of the seaward extension of the ledge cropping out in the cuts.

It became very evident, after we had examined the south shore of the lagoon, that the ledge underlying the north shore is the remnant of the bed, an old tertiary coralliferous limestone, which at one time covered the greater part of the area of the lagoon, portions of which may have been elevated to a considerable height. This limestone was gradually denuded and eroded to the level of the sea. Passages were formed on its outside edge, allowing the sea access to the inner parts of the lagoon. This began to cut away the inner portions of the elevated limestone, forming large sounds, as in the case of Fiji atolls, and leaving finally on the south side only a flat strip of perhaps 2500 to 3000 feet in width which has gradually been further eroded on the lagoon side and also on the sea face to leave only a narrow strip of land about 1000 feet in width and perhaps 10 to 14 feet in height, the material for this land having come from the disintegration of the ledge of tertiary limestone, both on the sea face and the lagoon side.

There exist at the lagoon side of both Avatoru and Tiputa passes a number of small islets which also consist of this same tertiary limestone in process of disintegration and transformation to coral sand islets; two of these we found along our line of soundings, the one about 4½ miles from the north side of the lagoon, and the other about the same distance from the south shore. I am told that the eastern extremity of the lagoon is filled with islets and heads consisting of the same limestone rock so characteristic of the north and south shores of the lagoon.

The underlying ledge is not the remnant of a modern reef; its character is identical with that of the elevated limestones of Fiji which are of tertiary age, and the rock is in every respect the same as that I observed on many of the elevated islands of Fiji. The atoll of Rairoa is in a stage of denudation and erosion very similar to that of Ngele Levu, in Fiji, only in Ngele Levu the elevated limestone attains a height of about 60 feet. Our visit to the south shore of the lagoon, both on the lagoon side and on the sea face, left us no doubt regarding the character of the underlying ledge of the north shore. As soon as the south shore was sufficiently near, as seen from the lagoon side, for us to distinguish its character, we could see that the entire shore line was formed of a high ledge of limestone, honeycombed, pitted, and eroded, both by atmospheric agencies and the action of the waves in its lower parts both on the lagoon side and on the sea face. The great rollers of the weather side broke through between the columnar masses of the ledge into the lagoon, and as far as the eye could reach there extended a more or less continuous wall (which is described by Dana as he saw it sailing by in the *Vincennes*). But, on landing, we found this wall to be the sea face of the islands and islets which dot the weather side for the greater part of its length on the southwestern part of the lagoon. These islands and islets are entirely composed of coral sand and coral fragments, formed from the disintegration of the extension of the elevated ledge toward the inside of the lagoon to a distance of about 1½ to 2 miles; and along this very gradual slope of the islands forming the southern edge of Rairoa, corals grow profusely down to 6 or 7 fathoms of water, when the bottom runs into hard coralline bottom similar to that found on all the soundings taken across the lagoon.

The width of the larger islands is about 1000 to 1200 feet, the smaller islands and islets are less, some of the latter forming in reality mere sand buttresses at right angles to the great limestone ledge which flanks them all on the sea face and connects them on the weather side as if by a great wall, more or less broken, and shuts off the communication of the interior of the lagoon with the sea on that side.

The passages between the islands and islets illustrate well, only on a larger scale, the formation of the cuts, more or less silted up, which were observed on the northern face of the lagoon. Some of these passages are dry at low-water, others are partly filled by tide pools, others are entirely silted up by lagoon sand, only they are lower than the sand-blown land of the islands on either side.

Crossing over to the weather side of the southern land of Rairoa, in one of the passages between two of the islands we came upon the limestone ledge, from 12 to 14 feet high and about 40 to 50 feet wide, which formed the sea face of the islands and islets, and extended far to the westward as a great stone wall more or less broken into distinct parts. We found this ledge to consist of elevated limestone as hard as calcite, full of corals, honeycombed and pitted, and worn into countless spires and spurs, and needles and blocks of all sizes and shapes, separated by deep crevasses or potholes, recalling a similar scene in Ngele Levu on the windward side of the lagoon. In the pas-

sages the parts of the ledge which had not been eroded extended as wide buttresses, gradually diminishing in height till they formed a part of the lagoon flat and extended out below the recent beach rock which covered it in short stretches.

The slope of the sea face of the elevated ledge was quite steep and similar to the lagoon slope, its upper surface weathered by atmospheric and aqueous agencies into all possible shapes such as I have mentioned. The slope passed into the shore platform which was shaved down as it were to a general level surface. On the outer edge, within the line of the breakers, were growing Pocillopores in great abundance. This reef flat or shore platform, as well as the reef platform of the north shore, was strewn here and there with huge masses of the ledge of elevated reef rock torn from its outer shore. Similar rocks and bowlders occur on the lagoon side of the islands forming the outer lands of Rairoa; they are either torn off from the lagoon face of the outcropping ledge, or are parts of the ledge which have remained in place and have not been planed down to the base level of the reef.

The amount of water which is forced into such a lagoon as Rairoa is something colossal, and when we observe that there are but a small number of passages through which it can find its way out again on the leeward side, it is not surprising that we should meet with such powerful currents (7 to 8 knots in several cases) sweeping out of the passages on the lee sides.

The islands and islets of Rairoa are fairly well covered with low trees and shrubs and great groves of palm trees.

The atolls of Tikehau and Mataiwa, which we also examined, present no features which we did not meet in Rairoa. The first-named atoll shows the same method of formation of the land by material piled up both from the lagoon side and the sea face; material derived from the disintegration of the underlying tertiary limestone which crops out here and there along the sea face and the inner shores of the lagoon, or forms across the southwest face of the lagoon a more or less disconnected part of the ring of islands and islets encircling that end of the lagoon. These islets and islands are irregularly connected by fragments of the elevated limestone ledge, attesting its greater extension in past times. The outer rings of both these atolls are covered with vegetation. We could see in the lagoons several rocky islets, the fragments of the elevated limestone ledge.

Mataiwa is interesting, as its lagoon is quite shallow; it is full of rocky islets, remnants of the underlying limestone ledge which crops out above the general level, and has a very narrow and shallow entrance, passable for boats only. Some of its islands are wooded and appear to have been formed by accretions of sand from the decomposing ledges of the lagoon. The outer ring of land appears formed by sand banks driven in from the sea face and driven out from the lagoon side by the action of the waves. It is evident that such a lagoon as Mataiwa could readily be closed to any access to it by the sea, as it now has only one very narrow and very shallow boat passage connecting the lagoon with the sea on the lee side.

It was with great interest that we approached Makatea, as it is the only high elevated island of which Dana speaks as occurring in the western Paumotus. For though he mentions some others as possibly having been elevated 5 to 6 feet, yet he considered them, all as well as Makatea (Metia or Aurora, of Dana), as modern elevated reefs. Yet from the very description given by him of the character of the cliffs and of the surface of Makatea, I felt satisfied that it was composed of the same elevated coralliferous limestone so character-

istic of the elevated reefs of Fiji, and which, from the evidence of the fossils and the character of the rock, both Mr. Dall and myself have been led to regard as of tertiary age.

As we approached the island from the northwest it soon became evident that it presented all the characteristics to which I had become so accustomed in Fiji, and, upon landing, this was found to be the case. The cliffs had the same appearance as those of Vatu Leile, Ongea, Mango, Kambara, and many other elevated islands of Fiji. There were fewer fossils perhaps, but otherwise the petrographic character of the rock was identical with that of Fiji. Mr. Meyer collected upon the top of the second terrace a number of fossils similar in all respects to those we found in the Fiji elevated coralliferous limestones.

The southwestern extremity of the island sloped gradually to the sea and showed two well-defined terraces. The lines of these two terraces could, as a rule, be traced along the faces of the vertical cliffs by the presence of caverns along the lines of those levels, similar to the line of caverns indicating the line of present action of the sea at the base of the cliffs. As we steamed around the island there were distinct indications of two additional terraces on the line of the vertical cliffs on the weather side of the island. The position of these terraces was usually more clearly seen along the face of the cliffs at prominent points where they were undercut much as I have figured them for certain cliffs in Vatu Leile, in Fiji, in my report on the islands and coral reefs of that group.

Of course it is premature from this examination of the western extremity of the Paumotus to base any general conclusions regarding the mode of formation of these atolls; certainly as far as I have gone there is absolutely nothing to show that the atolls of the Paumotus have not been formed in an area of elevation similar to that of Fiji. The evidence in Rairoa and in the atolls of the western Paumotus is very definite. Makatea is an elevated mass of coralliferous limestone similar in all respects to masses like Vatu Vara, Thithia, and others in Fiji. Like them Makatea is surrounded by a comparatively narrow shore platform cut out from the base of the limestone cliffs and on the seaward extension of which corals grow abundantly to depths of 7 to 8 fathoms, when they appear to become very much less numerous. So that it is not unnatural, as I am inclined to do, to look upon the area of the Paumotus as one of elevation, the raised and elevated land of which has been affected much in the same way by denudation and erosion as have the masses of elevated coralliferous limestone of Fiji. Only there seems to have been, from the evidence thus far presented, a far greater uniformity in the height of the elevation of the Paumotus. This would render the explanation I have given less evident had I not the experience of the Fiji group to guide me. I am informed that there are other islands and atolls in the Paumotu group, showing traces of this elevation, so that I am at any rate justified in denying that the Paumotus as such are situated in an area of subsidence and that subsidence has been the great factor, as is maintained by Darwin and Dana, in the formation of the characteristic atolls of the group.

It may be well to point out also that the Paumotus, like the Marquesas on one side and the Society Islands on the other, are situated upon a plateau similar to that upon which the last mentioned groups are placed—this plateau having a depth of from 1200 to 1500 fathoms and rising from the general oceanic basin which surrounds them and which has a depth of from 2300 to 2500 fathoms. Furthermore, evidence of this elevation is found at the two extremi-

ties of the Paumotu plateau, at Makatea, an elevated island consisting of tertiary coralliferous limestone and at the Gambier Islands which are volcanic islands of considerable height.

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II.

THE REVISED HARVARD PHOTOMETRY.

IN the Harvard Photometry, all stars were inserted having the magnitude 6.0 or brighter in any of the principal star catalogues then published. Accordingly, as was expected, many fainter stars were included, since a star really faint, but estimated bright by mistake in any of these catalogues, would be entered and measured. It appears that from this cause, and from the varying scale in different catalogues, more than six hundred stars are included, which are fainter than the magnitude 6.2 on the photometric scale. (See H. C. Annals, Vol. XIV., p. 479.) Numerous measures of the brighter stars have been made in recent years, with the large meridian photometer which has replaced the instrument first used. They include 823 stars measured in connection with fainter stars in Vol. XXIV., Table I., and 1179 stars in Vol. XXIV., Table IV. Measures of all of the bright stars south of declination — 30°, are published in Vol. XXXIV.

The stars of the Harvard Photometry were again observed in 1892–1894, and the results are now being published in Vol. XLIV. A large number of them were also measured in 1895–1898, when determining the brightness of stars of the magnitude 7.5 and brighter north of declination — 40°. Finally, the stars south of declination — 30° are now being remeasured in Arequipa, by Professor Bailey. In a recent letter, he states that sixteen series were obtained on sixteen successive nights, and that 11,448 settings were made during the month of May, 1899. It is hoped that this work will be completed during the present year.

It, therefore, appears that seven photometric catalogues of these stars have been prepared. In Vol. XXIV., Table I., some stars were observed on only two nights, but in all the other catalogues the minimum number of nights is three, and for many of the stars, especially for those that are bright, the number is much greater. When the observations were not accordant the minimum number of nights was five in Vol. XXIV., Part I., and seven or more in the other catalogues. The number of photometric settings on each star each night was generally four, but was occasionally eight or more in the later work. The total number of photometric settings, including those of the fainter stars, will slightly exceed one million. It will be seen, therefore, that a large number of measures of all the bright stars have been made according to the same plan, but with different instruments and by different observers. Each star should appear in at least two of the seven catalogues, and generally in three or more.

It is, therefore, proposed to issue a catalogue of all the stars from the north to the south pole of the magnitude 6.0 or brighter according to the meridian photometer, which will show the brightness as given in each of the seven catalogues. This work, which will be called the 'Revised Harvard Photometry,' will also contain other facts, such as the approximate right ascension and declination for 1900; the designation according to Bayer, Flamsteed, the *Durchmusterung*, the Argentine General Catalogue, the Harvard Photometry and the Southern Harvard Photometry; the magnitude according to Herschel, the *Durchmusterung*, the Argentine General Catalogue, the *Uranometria Oxoniensis*, and the Potsdam Catalogues; the class of spectrum, and, if pos-

sible, the photographic magnitude. This would also furnish a quantitative measure of the color.

As it is believed that this catalogue will be found convenient for general reference, the value would be greatly increased if the precise position, the precession, the secular variation, and the proper motion were added. This does not seem advisable, however, since owing to the uncertainties of proper motion, and systematic errors in various catalogues, the labor involved in this work would be very great, and probably many astronomers would be dissatisfied with the results, however obtained. A simple plan would be, for the northern stars, to take the positions for 1875 given in the catalogues of the *Astronomische Gesellschaft*, and for the southern stars those given in the Argentine General Catalogue. Residuals for a few other catalogues could be given and thus permit other places to be used if desired. These positions would be sufficiently accurate for stars of the eighth and ninth magnitudes, but they would be far from representing the accuracy with which the places of the brighter stars are known. Any suggestions and criticism relating to the above plan will be gratefully accepted, as it is not yet too late to make use of them.

G. C. Comstock : *Some Researches in Stellar Color.*

By placing a coarse grating in front of the objective of a telescope the image of a star is broken up into a series of spectra symmetrically placed on opposite sides of a central image, and, as is well known, the distance of the several spectra from the central image depends upon the grating interval and the wave-length of the light in question. When the grating interval is large, *e. g.*, 10 mm. to 50 mm., the first order spectra of stars are almost indistinguishable from stellar points, and if their angular separation is measured with a filar micrometer an excellent determination of the mean wave-length of the light in question is easily obtained. Observations of this kind are in progress with the 40 cm. equatorial telescope of the Washburn Observatory, special attention being given to colored stars and to the planet Mars for the purpose of determining any possible effect of the stellar and planetary color upon observations for the determination of the solar parallax. While definite results are not yet obtainable, it may be stated in general that the mean refrangibility of the light of Mars is markedly less than that of any red stars yet examined.

Attention has also been given to the color of Jupiter's satellites on account of the application of interference methods to the determination of their diameters made by Michelson and Hamy. Both of these investigators appear to have assumed too small values of the mean wave-length, that of Hamy requiring to be reduced about twelve per cent.

F. L. Chase : *Refraction of Red Stars.*

Gill in 1877 and Newcomb in 1895 have spoken of the importance of the effect that a difference in the refraction of Mars and minor planets from that of the comparison stars might have on the apparent parallaxes of the planets. Although feeling that in case of *Victoria* and *Sappho* this color effect was inappreciable, as stated in his recent work on the solar parallax, Dr. Gill requested the several observatories engaged in the solar parallax work to make a short series of heliometer observations on several highly colored stars. Not having time to carry out the program suggested by Dr. Gill, the author selected five other suitable stars and carried out the work as follows:

The plan was to observe the distances between the red star and each of two nearly equally distant comparison stars, one preceding in right ascension and the other fol-

lowing it, and as nearly as possible on the same parallel of declination with it, first at a rather large hour angle when east of the meridian and again in the morning hours when west. Now it is evident that if the red star is lifted less by refraction than a comparison star which precedes it in right ascension, the distance between them on the east side of the meridian will be greater than it would be if both stars were white and less on the other, and *vice versa* if the comparison star follows it. By taking two comparison stars as described above we are able to eliminate any change in the scale value, any variation in the atmospheric refraction, and the difference of the two measured distances would evidently give double the effect we are considering.

Now the refraction of a star of average color may be represented by

$$R = \beta \tan z.$$

The refraction of a star with light of a different refrangibility would then be

$$R = (\beta + d\beta) \tan z.$$

It will therefore be easily seen that the refraction correction to the observed distance between two stars of different refrangibility should receive an additional correction

$$- d\beta \tan z \cos (p - q),$$

z, p and q having their usual significations of zenith distance, position angle, and parallactic angle, respectively.

To each measured distance it would then be simply necessary to add the term

$$- d\beta \tan z \cos (p - q)$$

and to find the value of $d\beta$.

Now for finding of the value of $d\beta$ the observations of each of the five red stars which were to be observed four times on each side of the meridian, would furnish eight equations of condition of the form

$$x + a d\beta = n,$$

where x is the necessary correction to the assumed value of the difference between the distances from the two comparison stars; a is the value of $\tan z \cos (p - q)$, and n is the observed difference of the two distances minus the assumed difference.

Combining the normals derived from these equations of condition for the observations of both last year and this, and solving, I find the following values for $d\beta$:

Star.	Redness.	$d\beta$.	Wt.
R_1	6.0	$+0.''020 \pm 0.''015$	63.6
R_2	7.1	$-0.''008 \pm 0.''014$	16.0*
R_3	7.0	-0.015 ± 0.020	64.4
R_4	8.7	-0.046 ± 0.018	45.2
R_5	7.8	$+0.008 \pm 0.024$	55.7

Average probable error 1 observation $= \pm 0.''151$.

A separate investigation was made along with that of star R_5, which was specially selected because it had a close neighboring white star. The distances of the white star from the same comparison stars were measured on the same nights and the observations were made symmetrically with respect to those of the red stars, so that the conditions were absolutely the same for the two stars.

Similar equations for this white star gave

$$d\beta = + 0.''004 \pm 0.''022, \text{ wt. } 55.6$$

as compared with $+ 0.''008 \pm 0.''024$ for R_5.

The small values above found for $d\beta$ (in the mean for five red stars we find $d\beta = - 0.''006 \pm 0.''010$), and more especially the fact that two contiguous stars, one white and the other red, give no appreciably different results, afford rather forcible evidence that to my eye, at least, difference of color in the stars does not effect heliometer observations of distance.

J. E. KEELER: *The Ring Nebula in Lyra.*

In order to test the capabilities of the Crossley three-foot reflector of the Lick Observatory, a number of photographs were made of well-known celestial objects. As the focal length of a camera should be from thirty to sixty times its aperture in order

* Not observed in 1899.

that the photographic and optical resolving power may be equal, it is doubtful if this nebula has ever been photographed with an entirely suitable instrument. As it is a small object and photographically bright, it could be advantageously photographed with a reflector of unusually long focus. The lenses of refractors absorb the actinic rays to such an extent that for such instruments exposures of even twenty hours have been given to this nebula. With the Crossley reflector, under the finest conditions, on July 14th of this year, an exposure of 30 seconds produced an image which was barely visible; one minute a faint image; two minutes a distinct image, and ten minutes exposure gave the best general picture of the nebula. With one and two hours the plate was much overexposed. The focal length of this telescope is $17\frac{1}{2}$ feet, but if it were four times greater a far better photograph could doubtless be obtained, the necessary exposure then being about three hours.

The ratio of aperture to focal length could, however, be reduced by cutting down the aperture, thus diminishing the aberration and atmospheric disturbances. But for an object like this nebula the aberration is insensible, the star images being excellent at half an inch from the axis; moreover the photographs were taken on nearly perfect nights when the definition would not have been improved by reducing the aperture.

These photographs of the ring nebula show features described by observers with powerful visual and photographic telescopes, and others which appear to be new. The outline of the nebula is oval rather than elliptical, with faint structureless fringes of nebulosity projecting on both sides of the oval. The ring has quite a complicated structure, as if made up of several narrower bright rings, interlacing somewhat irregularly, the intervening space being filled with fainter nebulosity.

A comparison was given of the dimensions of the nebula as measured by Barnard with the Lick refractor, and as determined by Stratonoff on photographs obtained in 10 hours exposure with a refractor of 33 cm. aperture, and as measured on a Crossley plate with 10 minutes exposure. The author's measures give a somewhat greater size than the visual measures, and also average slightly more than on the Russian photograph.

Lord Rosse's drawing, published in the *Philosophical Transactions* for 1844, showing the interior space of the nebula to be crossed by a series of dark and bright bands, and hitherto generally deemed fanciful, is now confirmed, it is believed, for the first time.

The actinic power of the central star, noted by many observers, is also confirmed by these plates, being faintly visible on the plate exposed for thirty seconds. It is suggested that the photographic strength of this and other central stars may be due to bright lines, probably of hydrogen, in the upper spectrum; and the author does not anticipate difficulties in photographing their spectra. On all the photographs the central star is as clearly defined as are other stars outside the nebula; there is no evidence of blending into the nebulous background. This is also the appearance of the star as seen with the 36-inch refractor. (Published in the *Astrophysical Journal.*)

W. W. CAMPBELL: *The Wave-length of the Green Coronal Line.*

One of the problems undertaken by the expedition sent from the Lick Observatory to observe the Indian eclipse of January 22, 1898, was the determination of the rotation of the corona from the displacement of the green coronal line. A powerful train of prisms loaned by Professor Young furnished the necessary high dispersion. A successful plate was obtained during the eclipse, and while measuring this in January, 1899, I learned that Lockyer had assigned a new wave-length to the green coronal line. On

reducing my measures, with the aid of Hartmann's formula, I obtained a result in substantial agreement with his. The wave-length is

For East side, λ 5303.21
For West side, 5303.32
Mean, λ 5303.26,

which should not be in error by more than ± 0.15 tenth meters. The difference in the determinations for the two sides corresponds to a relative velocity of 6.2 km. in the line of sight, or a rotational velocity of 3.1 km. per second. However, I regard this result as subject to a possible error of at least ± 2 km. per second, partly on account of unavoidable errors of observations, but principally on acount of the ill-defined and unsymmetrical character of the bright line.

The continuous spectrum of the inner corona was recorded out to a distance of 2.′5 on the east side and 1.′5 on the west side. While the dark lines in the recorded comparison spectra are sharp and strong, there is not the slightest trace of dark lines in the recorded continuous spectrum of the corona. This radiation seems to be of coronal origin, and is not due to reflected photospheric radiations.

In explanation of the error in the accepted value of the wave-length (λ 5317) of the green coronal line which has prevailed for many years, it is suggested that the true coronal line would be difficult to observe so long as the chromospheric spectrum was visible. Hence the observers, setting on the strongest chromospheric line in this region, at λ 5317, which is very conspicuous just before and at the instance of totality, assumed it to be identical with the true coronal line, and located it at 1474K. Later, when this line had disappeared, rather suddenly, and the background had become dark enough to allow the line at λ 5303 to be seen, the observers were interested in the extent and other properties of the line and no further micrometer settings were made for fixing its wave-length. (Published in the *Astrophysical Journal.*)

EDWIN B. FROST: *Notes on the Reduction of Stellar Spectra.*

The advantage was pointed out of using Hartmann's interpolation formula for the prismatic spectrum in the reduction of spectrograms taken either for the determination of wave-lengths or velocity in the line of sight. An outline was given of the procedure adopted in the latter work with the 40-inch refractor. Each plate is reduced by itself, independently of any solar or other plate, such as many observers have used as auxiliary in the process of reduction. The comparison spectrum from a spark between metallic electrodes, impressed upon each plate, furnishes all the data necessary for reduction. It is hoped that errors due to effects of temperature on the dispersion of prisms and focus of lenses are thereby reduced, and that systematic errors are also diminished.

Attention was called to the favorable results obtained from the use of titanium as a source of the comparison spectrum. The lines are numerous and well distributed throughout the upper spectrum. The metal stands third in Rowland's arrangement according to number of lines in the solar spectrum. The spark passes with great readiness between electrodes of metallic titanium, and the air lines, which are annoying in case of the spark spectrum of iron, are not produced. Sharp titanium lines are found to fall at points in the spectrum close to the positions of the principal lines of stellar spectra of Type 1*b*, and thus facilitate the reduction of such spectra.

Corrections to Determinations of Absolute Wave-length.

The effect upon the absolute wave-length of lines in the solar spectrum of the eccentricity of the earth's orbit seems to have

been hitherto neglected, presumably because the observers deemed it insignificant. The largest values, however, of the motion of the Earth toward and from the Sun, due to this cause, amount to 0.50 kilometer per second, in April and October ; and if velocities of stars in the line of sight were determined directly from absolute wave-lengths, instead of relative wave-lengths, uncertainties of one-half of a kilometer would at once arise, in measurements now given to the tenth of a kilometer. Expressed in wave-lengths that velocity would produce a displacement of 0.011 *tenth-meters* at *C*; or 0.008 at *F*.

The diurnal correction to velocities in the line of sight, due to the Earth's rotation, also seems to have been omitted in reducing measures of absolute wave-length. This might have an effect up to 0.006 tenth-meter at *C* or 0.005 at *F*.

The need of even a higher degree of accuracy than that yet obtained in relative wave-lengths was urged, as an error of 0.01 tenth-meter in the relative wave-length of either a stellar or comparison line (not coincident) whose separation is measured, produces an error of 0.7 kilometers per second in the velocity of the star as deduced from that line. (To be published in the *Astrophysical Journal.*)

FRANK SCHLESINGER: *Suggestions for the Determination of Stellar Parallax by Photography.*

As the star to be examined for parallax will usually exceed each of the comparison stars in brightness by six or seven magnitudes, the first problem is to reduce in some way most of the light of the brighter stars, in order to escape various errors which would arise in the measurement of star disks very unequal in size and appearance. It is suggested that the portion of the photographic film upon which the light of the principal star will fall be previously treated with some suitable dye, thus greatly reducing its photographic action.

To avoid a second source of error, distortion of the film after exposure, a modification of the method employed by Wilsing is suggested. Let two pictures be taken close to each other on the same plate at the first date; let the plate then be stored undeveloped in a dark room ; after six months make two more exposures of the same star and comparison stars on the plate at a little distance from the previous impressions; this plate can then be developed and measured, without fear of any ill effects from distortion of the film. The first pair of exposures on a new plate may then be begun, and this stored for six months; and so on until a sufficiently long chain of plates is secured to give good values both for the parallax and for relative proper motions with respect to comparison stars.

It is proposed that errors of optical distortion caused by peculiarities of the object-glass be eliminated from the parallax by rotating the lens in its own plane through 180° each time that the telescope is reversed. In this way the objective will present the same position relative to a stellar configuration, whether in the east or west, and optical distortion, if any, will shift all images of the same star alike.

According to the author's estimate, a single observer working 15 or 18 hours a week at the telescope and employing the rest of his time in measuring and reducing, could give us in three or four years the parallaxes of 200 stars with an accuracy hitherto attained for only a score. (To be published in the *Astrophysical Journal.*)

S. I. BAILEY: *Periods of the Variable Stars in the Cluster Messier 5.*

This cluster contains about 900 stars on the photographs made with the 13-inch Boyden refractor, of which about eighty-five, or one in eleven, are variable. The

periods of about forty stars have been determined from measures made of 63 of these variables on nearly 100 plates by the author and Miss E. F. Leland. The period and light curve of one of the stars in this cluster were determined by Professor E. C. Pickering in 1896, and the periods of three others by visual observations with the Yerkes refractor. A tabular statement was given of the periods, maximum and minimum brightness and range, and distance from the center of the cluster. Drawings were exhibited of the light-curves of the first eight variables in the group. The table disclosed a striking similarity among all these variables, not only in regard to length of period, but in magnitude and range of variation. Excepting No. 9, which has the exceptional period of $16^h\ 47^m$, the longest period among the 40 stars is $14^h\ 59^m$, and the shortest $10^h\ 48^m$. The average period is $12^h\ 37^m$, so that the greatest deviation in period from the mean is $2^h\ 21^m$. At maximum these variables range between 13.4 and 13.9 mags., and at minimum between 14.5 and 14.9 mags. The uniformity of period, magnitude, and light-curve among so many variables in the same cluster points unmistakably to a common origin and cause of variability. No such uniformity is found in the periods and light-curves of over one hundred variables determined by the author in the great cluster *ω Centauri*.

A few of the variables in M. 5 have been studied with special care for the exact determination of the form of the light-curve, and diagrams were shown of two of these, which represent what may be called the 'Cluster Type' of variables. The decrease in brightness is rapid, but not nearly so rapid as the increase. The duration of maximum phase is exceedingly brief, if any; the minimum brightness appears to be quite constant for several hours. The whole period may be divided as follows:

Duration of	maximum	phase	0	per cent.
"	" minimum	"	40	" "
"	" decreasing	"	50	" "
"	" increasing	"	10	" "

Note on the Relation between the Visual and Photographic Light-curves of Variable Stars of Short Period.

With a visual telescope of sufficient power a series of frequent observations of a variable star will give the true form of its light-curve, since each observation consumes so little time that it is not affected by the star's variability. The same would be true of photographic observations if the time of exposure could be made so short as to bear an inappreciable ratio to any change of phase. This applies to most long-period variables. Certain short-period variables, however, notably those belonging to dense clusters, are so faint and go through their changes, especially the increase in light, so rapidly, that the necessary exposure bears a very large ratio to the duration of any phase and important modifications in the form of the light-curve follow.

When the light of a star is changing at a uniform rate and in the same direction, the measured magnitude will approximately represent the actual photographic magnitude at the middle time of exposure, but it is obvious that sharp changes in the light of a variable will not be well registered on photographs of relatively long exposure. A diagram was shown of an assumed light-curve, where the exposure required was one-half of the period of the star's entire variation, and the rise and fall of the brightness were equally rapid. Here no photograph of the required exposure would record a complete minimum, but would fall above it, and similarly would fall below the true maximum. Thus the tendency of the photographs is to smooth down the curve, reducing the star's apparent range of variation.

Where the increase and decrease of light

are of different rapidity, as is usually the case, the result will be different. A diagram was shown of a slightly modified light-curve of variable No. 7 of cluster M. 5. In order to represent the variable at a complete minimum the exposure must close before the beginning of the maximum phase. The photograph, the middle of whose exposure is at the beginning of maximum, will have the first half of its exposure at minimum and will record the variable as of less than maximum brightness, and the maximum possible on such plates will be recorded on the exposure commencing at the beginning of maximum. With the usual exposure of one hour for this cluster, the photograph beginning an hour before maximum would record the minimum photographic magnitude. This retardation will depend upon the light-curve and the exposure time. In general the difference in time between the photographed and the actual maximum or minimum varies, with zero as a limit, as the exposure is reduced. Evidently a large telescope and very sensitive plates are desirable.

Probably the shortest period yet found is that of No. 91 in *ω Centauri*, $6^h\ 11^m$; as it is not improbable that much shorter periods may be discovered, it is clear that the relation of the exposure to the period becomes very important. (To be published in the *Astrophysical Journal.*)

Neither the original papers nor abstracts have been obtained of the following:

WILLIAM HARKNESS: *On the Semi-Diameters of the Sun and Moon.*

F. R. MOULTON: *Problems in Modern Celestial Mechanics Treated by the use of Power Series. Laplace's Ring Nebular Hypothesis.*

The committee on the total solar eclipse of May 28, 1900, consisting of Professors Newcomb, Barnard, Campbell and Hale (Secretary), presented this preliminary report:

THE TOTAL SOLAR ECLIPSE OF MAY 28, 1900.

The committee on the total solar eclipse of May 28, 1900, appointed at the Second Conference of Astronomers and Astrophysicists, presents herewith a preliminary report.

The aim of the committee has been:

1. To ascertain the opinion of astronomers regarding the best means of securing coöperation, the most important classes of observations and the best means of making them, and the plans of the various eclipse parties.

2. To collect other information likely to be useful to persons planning to observe the eclipse.

For the purpose of securing information on the various points referred to in paragraph (1) a circular letter was addressed to American astronomers. From an examination of these replies it appears:

1. That there is a general willingness to coöperate with the committee in securing thorough observations of the eclipse phenomena and effective distribution of stations along the line of totality.

2. That, in the opinion of those from whom the replies were received, the most important observations includes studies of the minute structure of the corona, both visually and by means of large scale photographs; photography of the flash spectrum and determination of the wave-length of the green coronal line; measurement of the heat radiation of the corona; photographic search for an intra-mercurial planet.

3. That several institutions, including the Princeton, Lick, Naval, Goodsell, Chabot, Flower and Yerkes Observatories, will probably be represesented by well-equipped parties, while a considerable number of astronomers with good instrumental equipment will take part as individuals.

4. That no general appeal to the public for funds is required, as each institution will endeavor to secure the amount necessary for its work.

5. That the work already planned includes observations of contacts, photography of the corona with large and small cameras; visual and photographic observations of the spectrum of the sun's limb and of the corona; visual examination of the details of the coronal structure; measurement of the brightness of the sky at different distances from the sun; search for an intra-mercurial planet; and observations of the shadow bands.

A preliminary report on the weather conditions along the line of totality has been prepared by the Weather Bureau, at the request of the committee. From this it appears that interior stations are probably to be preferred to those on the seacoast, in spite of the shorter duration of the total phase. The full report of the Weather Bureau, which will soon be published, will contain much valuable matter, including maps of the eclipse track, showing location of towns and railways; information regarding hotel accommodations, desirable sites, etc.

It is understood that the Naval Observatory will issue instructions to observers, and that a map of the eclipse track will be published by the Nautical Almanac Office. The Treasury Department has made arrangements by which the instruments of foreign parties will be admitted free of duty.

The committee, if authorized by the conference to continue its work, will be glad to receive and publish further information from eclipse parties regarding their plan of observations and location of stations.

Extracts from the replies of various astronomers were appended to the report, but need not be reproduced here, as they have been published in the *Astrophysical Journal*. The committee was continued in office.

The committee appointed at the Second Conference to act in reference to the questions at issue regarding the United States Naval Observatory also reported that the opinions of astronomers regarding that institution, which had been obtained in response to a circular letter, had been communicated to the Secretary of the Navy. This report is not reproduced here, as it is practically superseded by the official report of a Board of Visitors appointed by the Secretary of the Navy to visit, examine and report upon the Naval Observatory. The recommendations of this official report have been given in full in SCIENCE.

The first meeting of the Astronomical and Astrophysical Society of America adjourned at noon, September 8th.

EDWIN B. FROST,
Acting Secretary.
YERKES OBSERVATORY, WILLIAMS BAY, WIS.

AMERICAN ORNITHOLOGISTS' UNION.

THE Seventeenth Congress of the American Ornithologists' Union convened in Philadelphia, on Monday evening, November 13th. The business meeting was held in the Council Room, and the public sessions, commencing Tuesday, November 14th, and lasting three days, were held in the Lecture Hall of the Academy of Natural Sciences.

Robert Ridgway, of Washington, D. C., was reëlected President; Dr. C. Hart Merriam, of Washington, D. C., and Charles B. Cory, of Boston, Vice-Presidents; John H. Sage, of Portland, Conn., Secretary; and William Dutcher, of New York City, Treasurer. Charles F. Batchelder, Frank M. Chapman, Ruthven Deane, Witmer Stone, Drs. A. K. Fisher, Jonathan Dwight, Jr., and Thos. S. Roberts, were elected members of the Council. By a provision of the by-laws, the ex-Presidents of the Union, Drs. J. A. Allen and Elliott Coues, and Messrs. William Brewster and D. G. Elliot, are *ex-officio* members of the Council.

Two corresponding and eighty-five associate members were elected.

Miss Juliette A. Owen, of St. Joseph, Mo., an associate member, donated $100 to the Union 'to be devoted to any ornithological purpose that might seem fitting to the Council.' Miss Owen wrote that the amount sent was about the cost of the journey she expected to take in order to attend the Congress, but was prevented from going. The sum received will be the nucleus of a fund which it is hoped may be secured, the income to be spent for the advancement of the science of ornithology.

An honored visitor to the daily sessions was Dr. Samuel W. Woodhouse, of Philadelphia, after whom Prof. Baird named the Woodhouse's Jay (*Aphelocoma woodhouseii*) more than forty years ago. Dr. Woodhouse is in most excellent health and still interested in scientific work.

Mr. Louis Agassiz Fuertes exhibited and explained a series of field sketches made by him in Alaska the past season. They showed the true life colors of the soft parts, mostly in the breeding season.

By courtesy of Miss Lucy H. Baird, Mr. Witmer Stone was able to compile and read the letters of John J. Audubon to the late Spencer F. Baird, then of Carlisle, Pa. These covered the period from the reply to the inquiry of the lad Baird concerning the identity of a flycatcher until after the return of Audubon from the Missouri river in 1843. The letters are of great historic interest and show the warm feeling of the older naturalist toward his young friend and companion.

Wednesday afternoon was devoted to papers illustrated with lantern slides. The following papers were read:

'An Account of the Nesting of Franklin's Gull (*Larus franklinii*) in Southern Minnesota': Dr. Thos. S. Roberts; 'Bird Studies with a Camera': Frank M. Chapman; 'Home Life of Some Birds': Wm. Dutcher. 'The Effects of Wear upon Feathers,' Dr. Jonathan Dwight, Jr.; 'Slides—Series of Kingfisher, Gulls, etc.': Wm. L. Baily.

In a pleasing conversational way Dr. A. K. Fisher told of the more interesting birds found by the recent Harriman Alaskan Expedition. The notes of the birds referred to were imitated by Mr. Fuertes, also a member of the Harriman party.

The report of the Committee on Protection of North American Birds, read by its Chairman, Mr. Witmer Stone, showed that an increased interest is taken at the present time in the preservation of wild bird life. Investigation proved that many of the birds now used in millinery were imported from countries where there are no bird laws. The committee had used its influence to prevent excessive collecting of eggs and skins for commercial purposes.

On Friday, November 17th, after adjournment of the Union, at the invitation of Mr. W. H. Wetherill, owner of the property, Mr. George Spencer Morris conducted a party to Mill Grove, on the Perkiomen, the former home of Audubon. Mrs. Morris F. Tyler, of New Haven, Conn., wife of the treasurer of Yale University, a granddaughter of Audubon, was one of the party.

The attendance of members at the Congress just closed was much larger than at any previous one. They came from distant parts of the United States, and from Canada.

Following is a list of the papers read at the sessions in addition to those already mentioned:

Notes on the Flammulated Screech Owls: Harry C. Oberholser; Three Years' Migration Data on City Hall Tower, Philadelphia: William L. Baily; A Quantitative Study of Variation in the Smaller American Shrikes: Reuben M. Strong; Behring Sea Arctic Snowflake (*Passerina hyperborea*) on its Breeding Grounds: C. Hart Merriman; On the Plumage of Certain Boreal Birds: Frank M. Chapman; On the Perfected Plu-

mage of *Somateria spectabilis*: Arthur H. Norton; The Summer Molting Plumage of Eider Ducks: Witmer Stone; An Oregon Fish Hawk Colony: Vernon Bailey; The Sequence of Plumages and Molts in Certain Families of North American Birds: Jonathan Dwight, Jr.; The Ranges of *Hylocichla fuscescens* and *Hylocichla f. salicicola*: Reginald Heber Howe, Jr.; On the Occurrence of the Egyptian Goose, (*Chenolopex ægyptiaca*) in North America: Frank C. Kirkwood; Further Remarks on the Relationships of the Grackles of the Subgenus *Quiscalus*: Frank M. Chapman; A Peculiar Sparrow Hawk: William Palmer; The Requirements of a Faunal List: W. E. Clyde Todd; Language of the Birds: Nelson R. Wood; A New Wren from Alaska: Harry C. Oberholser; The Molt of the Flight-Feathers in various Orders of Birds: Witmer Stone; Some Cuban Birds: John W. Daniel, Jr.; On the Orientation of Birds: Captain Gabriel Reynaud, French army.

The next meeting will be held in Cambridge, Mass., commencing November 12, 1900.

JOHN H. SAGE,
Secretary.

DEMONSTRATING THE CURVE OF THE BASE BALL IN THE LECTURE ROOM.

THE limited space in the lecture room, and the presence of one's audience makes a demonstration of curve pitching difficult even if one has the necessary skill. If the curve is to be made at all apparent in a limited space the ball must be exceedingly light, and the axial rotation very rapid.

I have found the ordinary oak-ball or oak-apple very suitable for this purpose. The rough surface gives the necessary friction, and the ball itself is as light as an egg shell and much stronger.

A strip of rubber band about 15 cms. long and 0.5 cm. wide is wound under tension around the ball (two or three turns are enough), and the ball 'catapulted' forward by means of the remainder of the band as shown in the figure. The ball will rise,

drop, or curve to one side, according to the position in which it is held. A total deflection of 45° is easily obtained, and when pitching the rise (which is the case shown in the figure) the ball, starting in a horizontal direction, will sometimes ascend half way to the ceiling. This curve is the most striking of course, as the attraction of gravitation is overcome. It shows to the best advantage when thrown directly away from the observer, but this of course is difficult in the lecture hall.

These oak balls are also very suitable for showing the suspension of a ball in an air jet.

R. W. WOOD.

THE ANNUAL REPORT OF THE SECRETARY OF AGRICULTURE.

THE report of the Secretary of Agriculture for 1899, just issued, shows that the Department has had a prosperous year and that the volume of its practical and administrative work has largely increased. At the same time there has been advancement in a number of lines of technical and scientific work.

The extension of the Weather Bureau service around the Carribean Sea has been abundantly successful in noting the first indications of cyclones and forecasting their movements. Warnings of cold waves have been particularly successful during the past year. A climate and crop service has been successfully established in Cuba and Puerto Rico, and similar work in Alaska has been extended into the interior. The records of

temperature, pressure and humidity, secured at 17 stations where 1200 ascensions of kites were made, have been collated, giving for the first time in the history of meteorology a large number of facts as to the average gradient of temperature up to six or eight thousand feet "free from all injurious influences and for so many days and over such a large region of country that it has a broad significance."

The Division of Chemistry has made important additions to its investigations of soils, including methods of analysis, foods and sugar beets. A special line of work the past year has been the study of preservatives of all kinds which may be used on meats.

The Division of Entomology reports the successful importation of *Blastophaga grossorum* for the fertilization of the flowers of the Smyrna fig trees which are largely grown in California. The study of injurious insects that may invade our territory from contiguous countries has been continued. Investigations are being made regarding the transmission of disease by house flies and mosquitoes. The San José scale, Mexican boll-weevil and insects injurious to growing crops, grasses and tobacco are among the other subjects of investigation in this Division on which considerable progress has been made recently.

The Biological Survey has extended its work on life zones, specially on the Pacific Coast. Several life zones have been run from the bottom of the Sacramento and San Joaquin valleys to the summit of the Sierras. The collection of bird stomachs which this division has accumulated during the past 14 years, numbers 31,300 specimens, about 2000 of which were examined in the laboratory the past year. Considerable work has been done to determine whether birds show marked preferences in selecting food or simply eat what is most abundant.

The Division of Vegetable Physiology and Pathology has been studying diseases affecting timber, the 'little-peach' disease, pear blight, diseases of white and sweet potatoes, a fungus disease attacking sea-island cotton, peach leaf curl, and diseases of lemon, orange and walnut trees. This Division is doing much more work than formerly on the hybridization and breeding of plants, including oranges and other citrous fruits, raisin grapes, corn and wheat. It has also undertaken elaborate investigations in coöperation with the Division of Soils on curing and ermentation of tobacco. "It has been found that the flavor and aroma are due not to bacteria, as was formerly supposed, but to enzymes or oxidizing agents in the leaf itself. The formation of these oxidizing agents and the conditions of their greatest activity are being studied."

The Division of Pomology has continued experiments with a view to the successful production of the finer table grapes of Europe, and has also made investigations in root grafting.

The work of the Division of Forestry has been reorganized during the year. A large amount of practical advice and assistance is being given to farmers, lumbermen and others in handling their forest lands, in a number of different States. The rate of growth of the loblolly pine in North Carolina, and the red or Douglass fir in Washington, has been studied, as well as their special qualities in forestry. Forest fires have been studied historically, and in the field, and the records of more than 5000 fires have been compiled and classified. The Secretary urges that this division be given a largely increased appropriation "to take advantage of the unprecedented opportunities created by the rapid public awakening to the meaning and value of practical forestry."

The Divisions of Soils has considerably extended the investigation and mapping of

the alkali soils of the irrigated districts of the West. Special studies of alkali soils have been made in the Yellowstone Valley in Montana and Pecos Valley in New Mexico, and in the vicinity of Salt Lake City, Utah. Soil surveys of Maryland and of Louisiana have been undertaken in coöperation with local agencies. Investigations of tobacco soils have been extended.

The Division of Agrostology has continued its work on native and cultivated grasses and forage plants with reference to the needs of the arid and semi-arid regions of the West. Studies of plants suitable for binding sands along sea shores and about the Great Lakes have been made in different parts of the country. Several native sand-binders of great promise have been discovered and their utilization, in a practical way, has been undertaken.

The examination of the work of the agricultural experiment stations made by the Office of Experiment Stations shows that these institutions are being more and more appreciated by the farmers and are doing more thorough and satisfactory work.

"The relations of the Department of Agriculture to the experiment stations made by several States become closer every year. An increased amount of assistance is given every year to the State experiment stations to enable them to carry out work of a national character. Coöperative work between the Department and the stations is gradually increasing. The Department is consulted oftener regarding the organization and management of the stations, the choice of officers, the lines of work to be undertaken, the execution of special work, plans for station buildings, materials and apparatus required for use in connection with the different kinds of agricultural investigation, etc."

The need of the establishment of experiment stations in Puerto Rico, Hawaii and the Philippines is strongly urged, and an appropriation for this purpose is asked for. Satisfactory progress has been made in the establishment of experiment stations in Alaska. The investigations on human nutrition, in charge of this Office, have been continued under the direct supervision of Professor Atwater, with headquarters at Middletown, Conn., and a number of reports have been published. The organization and development of the irrigation investigations, also in charge of this Office, have rapidly proceeded during the past year, and work is now done in this line in fifteen States and Territories. Professor Elwood Mead, formerly State Engineer of Wyoming, has been in charge of this work, and headquarters have been regularly established at Cheyenne, Wyo. This work includes studies of the laws and administrative regulations in the irrigated region and investigations on the supply of water. The need and importance of this work are dwelt upon at considerable length by the Secretary, and its national aspects are pointed out.

The Office of Road Inquiries is working in coöperation with local authorities in building sample roads from the materials found in different localities and in the laying of steel track.

The Section of Foreign Markets has made special studies regarding the trade of the Philippine Islands, Puerto Rico and Cuba, and of Danish imports from the United States. The record for 1898 shows that our agricultural exports were decidedly the largest in the history of the country, their total value reaching over $850,000,000.

The meat inspection, conducted by the Bureau of Animal Industry, has reached very large proportions. During the past year it was conducted in forty-one cities, and the total number of ante-mortem inspections of animals was 53,223,176. Encouraging results have come from the efforts of the Department to increase the export of

dairy products. The investigations of the Bureau which have resulted in the preparation and distribution of serum for the prevention of hog cholera, swine plague, and blackleg have proved to be very successful. The loss from these diseases has been materially reduced when the treatment recommended by the Department has been followed.

The Division of Statistics has studied the condition of the agricultural industry of the country "as indicated by the area of land devoted to the cultivation of the principal products of the soil; the actual volume of production and the value of particular crops, both on the farm and in the principal markets; the cost of production per acre and per unit of quantity and the cost of transportation; the number and value of farm animals and the losses annually resulting from disease and exposure; the volume, condition and prospects, according to the season of the year, of such of the crops of foreign countries as compete with those of the United States in the world's markets."

The Secretary reviews at some length the subject of seed distribution. He warmly defends such distribution in so far as it adheres to the original intention of Congress, which was to search for and gather in various localities of the Old World useful seeds and plants to be distributed in the United States to the several regions where they would be most likely to succeed. The Department is at present endeavoring to bring back the practice as much as possible to this original intention, a larger per cent. of the $130,000 appropriated being now spent in securing, importing and distributing rare and useful seeds and plants.

The tea growing experiments in South Carolina are commended and their intelligent prosecution advocated. The interesting fact is noted that the tea gardens at Summerville produced 3,600 pounds of tea the past season. Irrigation experiments, improvement of varieties by importation and by hybridization, are indicated as important steps to be studied.

In regard to public lands, the Secretary deplores the ill results of injudicious grazing due to the indifference of the occupiers under the present system. He advocates leasing in large areas and for a sufficient time to invite improvement, and suggests that the revenue from such leases might be turned over to the States for educational purposes or irrigation.

The Secretary concludes his report with important recommendations on a variety of subjects.

Of the abandoned farms of New England he says that they are not abandoned on account of sterility; that they will be studied by the soil physicist, agrostologist, and the forester, and the valuable suggestions resulting from their studies will be distributed throughout New England.

He urges that means be adopted to produce in Puerto Rico, Hawaii and the Philippines many of the tropical plants which this country now imports to the extent of $200,000,000 annually—more than four times as much as the total exports of the islands in question.

Our import of oranges, lemons, cocoanuts, bananas, and especially coffee, of which in 1898 we imported over $65,000,000 worth, could, in large part, be produced in Puerto Rico. The Secretary especially recommends experiments in the production of india rubber, for which we are now largely dependent upon Brazil. The import of india rubber and gutta-percha in 1898 exceeded in value $26,000,000, of which three-fifths came from Brazil. After discussing at some length the methods of collection and treatment and the character of the Brazilian product, he indicates one tree in particular, known as the Ceara, as likely to be the first to produce an important addition to the natural supply of

india rubber. He adds: "The feasibility of cultivating this plant in the Philippines should be very carefully investigated."

The Turkestan alfalfa introduced by the Department is warmly commended as successfully withstanding drought and cold. It is proposed to distribute it widely over the arid West, to be thoroughly tested, and its introduction is spoken of as likely to add millions of dollars to the annual hay product of the country.

A valuable rice has also been introduced from Japan. It possesses a high milling quality and is highly superior to the domestic product, and should it succeed in Louisiana, hundreds of thousands of dollars will be added yearly to the rice-growing industry.

In connection with the subject of native drug plants, coöperative work is proposed by the Department and the Pan-American Congress in a technical and scientific investigation of these plants; $10,000 is asked for to enable the Department to undertake this work. The great increase of cotton imports from Egypt, averaging in value for the past three years nearly 3¾ million dollars, lends importance to the experiments so far made with the Egyptian cotton seed imported by the Department in 1894. While a further trial is needed, hope is expressed, that with proper management, it will become well established in the United States.

Mr. Wilson makes a most urgent plea for the erection on the Department grounds of new laboratory buildings as a substitute for the numerous and inconvenient buildings, mostly dwelling houses, now occupied for laboratory purposes at a cost of $10,000 a year. He has caused plans to be prepared of fireproof structures providing an increase of floor space over the present accommodations and in every way more suitable and economical, to cost, approximately, $200,000.

The concluding portion of the report is devoted to a discussion of agricultural education. The Secretary holds that in view of the importance of agriculture in the economic life of the country, adequate measures for the efficient agricultural education of our people, nearly one-half of whom are engaged in agriculture, are lacking. He refers to the impossibility of securing, on demand from the Civil Service Commission, persons qualified to serve as assistants in the scientific Divisions of the Department. The training of the necessary experts has to be done in the Department itself, and then when their full measure of usefulness is attained, wealthy institutions take them from the service by offering much higher salaries than the Department is authorized to pay.

Arrangements have been made with the Civil Service Commission to make a register of the graduates of the land-grant colleges. From this register young men will be selected to assist in the scientific divisions at very small pay, but with special opportunities for post-graduate study such as no university in the land supplies. By this means it is hoped that the Department will have a force from which not only to fill vacancies when wealthy institutions take away the Department's trained men, but possibly, also, to supply agricultural stations and other scientific institutions with men of superior scientific attainments. This is a step intended to complete the educational system provided in the endowment of agricultural experiment stations and agricultural colleges. The work so proposed will entail but moderate expense, and the Secretary expresses the hope that it will meet with the approval of Congress. Reference is made to the gratifying evidence of growing interest in the subject of elementary instruction in sciences relating to agriculture, and to the progress made in this regard since the Secretary presented his last Annual Report.

During the year the Department issued

603 publications, aggregating 26,240 pages. The total number of copies was over 7,000,000; 4,000 volumes were added to the Department library.

SCIENTIFIC BOOKS.

Die Landbauzonen der aussertropischen Länder. By Th. H. Engelbrecht. Three volumes. Berlin, Dietrich Reimer (Ernst Vohsen). 1898. Royal 8vo.

These stately volumes were prompted, as the author's preface states, primarily by the question of American competition with European production; certainly a most timely topic. Vol. I., of 290 pages, contains the explanatory text for the other two, of which one consists of statistical tables of production, while Vol. III is an atlas of 79 colored maps, the graphic representation of results of comparisons made upon a basis somewhat different from the usual ones of total, or cultivated areas, or population. The author's object is to elicit the peculiar tendencies of agricultural production rather than its absolute quantities, and by the discussion of the causes of these tendencies to forecast present and future possibilities. He objects to the method of computation of the 'importance' of the several crops devised by Walker (amount produced divided by area population) as affording no definite clew to any inquiry as to causes.

Adopting for the extra-tropical countries the cereal grains as the fundamentally important product, Engelbrecht compares with the total area occupied by these, both those occupied by each individual kind, and by other crops. Correspondingly, in treating of the animal industries, he assumes neat cattle as the basis of comparison with other domestic animals. On the maps these comparisons are made by means of five, or at times six, shades of color, to which are frequently added important (mostly monthly) isotherms, as well as colored limiting-lines of the occurrence of important trees, of excess of production of one product over another, of limited special cultures, etc., whereby the comparisons are greatly facilitated and many interesting points are brought out. Thus, in Russia, the marked coincidence of the northern limit of the oak forest and of wheat culture is shown; in the United States, the limits between predominance of summer and winter wheat, of rice over wheat culture, etc.

For the Old World, where changes are very slow, the latest census has, as a rule, been utilized, and as there no uniformity of dates exist among the various states, the data represented are frequently of different dates. From the cause just mentioned these discrepancies are of minor importance; yet in the more progressive countries the establishment of new trade routes and connections following lines of railroads and steamships has even in Europe, in many instances, been followed by rapid changes in lines of production. In the case of the United States, with the rapid changes both in population and routes of communication, the comparison of several successive enumerations is given by means of tables.

In the Old World the maps are made to extend to the Ural mountains on the east, and southward so as to embrace Algeria and Tunisia. In America the map colors for the cereals reach a short distance only into Canada; for other products the Dominion is left in blank, although quite fully represented in the tables of Vol. II. In South America the Argentine Republic is included in the graphic presentation, as are, in Australia, the temperate culture belts of the east and west coasts. Cape Colony is also considered in the matter of animal industry.

In the United States the smallest units considered are the single States. In Europe the smaller administrative units—departments in France, 'governments' in Russia, in England, counties, are separately colored on the maps and listed in the tables; the results of several census periods are frequently given, both in tables and maps, and numerous minor cultures are included in detail.

Accustomed as we are to interpret intensity of coloration in statistical maps as a measure of absolute production, at first sight these maps strike one rather oddly. Thus when Ireland and western Lapland bear the same color in respect to the production of the potato, and Nevada and Arizona appear most intensely colored on the score of the production of barley, our geographical and economic consciousness is

shocked. But when we find that, rightly interpreted, these colors mean that in these cases the crops mentioned occupy areas in the ratio of 40% and 30%, respectively, to the total area of grain culture, we obtain unexpected information of a very definite character, which is at once complemented by an inspection of the maps showing the ratios of other crops, into a very fair picture of the agricultural adaptations and possibilities of these unfamiliar regions. On the map of Europe, we at once see the predominance of the most rapidly maturing grain, barley, in the north, while to southward oats become predominant, and finally maize. The discussion in Vol I. of the complex topographic, climatic, ethnologic and commercial conditions which bring about the existing state of production in the various countries included, is able and very interesting. But the author does not, apparently, trust himself to make any definite summary forecast of the future development of competitive production as between Europe and America; doubtless because in the detailed discussions he finds the determining factors to be numerous and so complicated with unforeseeable contingencies, especially in view of the phenomenal progress of transportation facilities and other consequences of industrial and technical progress, that he rests content with the presentation to the student of economics of a host of valuable facts and suggestions from which he may draw material for his own conclusions. It is noteworthy that, as the author admits, the United States maintains the most complete system of statistical enumeration, and thus, despite the mutability of its population, supply already at least as complete a picture of the climatic adaptations of production as does the more ancient but politically disjointed continent of Europe, with its multifarious methods of enumeration and numerous artificial barriers to development.

Engelbrecht's work is certainly of high interest to all students of the economics of agricultural production and commerce; and should find a prominent place in public libraries especially.

E. W. HILGARD.

Plant Relations. A first book of Botany. By JOHN M. COULTER, A.M., Ph.D., Head Professor of Botany in the University of Chicago. Twentieth Century Text-books. New York, D. Appleton & Company. 1899. Pp. ix + 264. 12mo.

In this pretty book, with its beautiful illustrations, the author presents 'a connected, readable account of some of the fundamental facts of botany,' in such a form as 'to give a certain amount of information.' The phase of botany to which attention is directed, is mainly that which in these later years we are calling ecology, and which hitherto has, to a large degree, been reserved for the later years of study in extended botanical courses in our universities. Dr. Coulter believes that the ecological view of the plant kingdom gives a proper conception of the place of plants in Nature, and is of more value to those who give but little time to the subject, while it serves as a fitting foundation for subsequent botanical studies.

After a short introductory chapter the foliage leaf is taken up and studied as an organ of the plant whose position, color, shape and structure are controlled by its light relations. The reader's attention is directed to many interesting phenomena, as the diurnal positions of leaves, sensitiveness of leaves, polarity, heliotropism, the relation of leaves to one another on erect and horizontal stems, etc. In the next chapter this is continued in a brief and summary discussion of the functions (photosynthesis, transpiration and respiration) and structure (gross structure, epidermis, stomata, mesophyll and veins) and protective devices (hairs, diminution of surface, rosette arrangement, profile position, etc.) of foliage leaves. Then follows a chapter on shoots, noting stems bearing foliage leaves (subterranean, procumbent, floating, climbing and erect), stems bearing scale leaves (buds, tubers and rootstocks), stems bearing floral leaves (life relations, structures, sepals, petals, stamens, etc.), and very briefly the structure of stems (dicotyledons and conifers, monocotyledons, ferns and 'lower plants'). In the chapter on roots the treatment is much the same (soil roots, water roots, air roots, clinging roots, prop roots, parasites, and a page on root structure). The reproductive organs are discussed under vegetative multiplication, spore reproduction, germination, dispersal of repro-

ductive bodies (by locomotion, water, air, forcible discharge, larger animals and insects). In like summary and interesting fashion the relations of flowers and insects are pointed out, the treatment being much too brief for the average reader with the limited acquaintance with flowers and flower structure which he is supposed to possess.

Half a dozen pages are given to a discussion of the struggle for existence among plants, the factors noted being decrease of water and light, changes in temperature and soil composition, devastating animals, plant rivalry, adaptation, migration and destruction. A dozen pages are taken up with the nutrition of plants, the principal topics being photosynthesis, the manufacture of proteids, digestion (14 lines), assimilation (5 lines), respiration and 'carnivorous plants.'

The remaining chapters (XI. to XV.) are given to a discussion of plant societies, in which the factors (water, heat, soil, light and wind) are first pointed out, followed by citations of examples of hydrophyte xerophyte, mesophyte, and halophyte societies, with suggestions as to their significance. Throughout the book the illustrations are superb, and add much to its value and interest.

As a summary of the ecological view of plant life for those already well grounded in botany, the book leaves little to be desired. It will be profitable reading for the student who has had what may be called General Botany in colleges and universities, but as a first book to be used by pupils in the secondary schools it will prove to be too difficult where thoroughness and accuracy are desired, otherwise it will be found too superficial. As a book for secondary schools it calls the attention of the pupil to many interesting phenomena, whose significance he can but vaguely comprehend because of his unfamiliarity with different types of plants. It is probable that the author recognized some of these difficulties after completing the book, as in the accompanying pamphlet of 'suggestions to teachers,' he says (p. 3) "if there has been no previous study of plants it will be necessary for the teacher at the outset, to train the pupils to recognize the great groups. This may be done in a series of laboratory exercises, which include comparison and drawing." Any teacher who has tried it, will say that the training of pupils 'to recognize the great groups' of plants ('algæ, mushrooms, lichens, mosses, ferns, gymnosperms, monocotyls and dicotyls, and if possible, liverworts, equisetums and club-mosses') is a pretty large undertaking for a half year's work, and if done well there will be little time left for the subject-matter of this book. Thus the author's own suggestions require a previous study of plants, and the book is therefore *not* a 'first book of botany.'

CHARLES E. BESSEY.
THE UNIVERSITY OF NEBRASKA.

SCIENTIFIC JOURNALS AND ARTICLES.

American Chemical Journal, October. 'On Potassium Cyanide as a Condensing Agent,' by A. Smith; 'Camphoric Acid,' by W. Noyes; 'The Action of Bromine on Metachlor-, Metabrom-, and Metaiodanilines,' by H. L. Wheeler and Wm. Valentine; 'A Simplification of Beckmann's Boiling-point Apparatus,' by S. L. Bigelow. The liquid is heated by passing a current of electricity through a platinum wire immersed in the liquid. 'A Contribution to our Knowledge of Dicarbonyl Cuprous Chloride,' by W. A. Jones.

November: 'The Rate of Action of Water on Certain α-, β-, and γ-Halogen Substituted Fatty Acids,' by E. De Barr; 'The Occlusion of Hydrogen by Metallic Cobalt and other Metals,' by G. P. Baxter; 'On the Nature of the Oxyazo Compounds,' by W. McPherson; 'A Contribution to the Study of Liquid Mixtures of Constant Boiling-point,' by G. Ryland; 'The Action of Benzoyl Chloride on the Phenylhydrazones of Benzoin,' by P. C. Freer; 'Notes on the Space Isomerism of the Toluquinoneoxime Ethers,' by W. C. Morgan; 'A Dissolver,' by A. J. Hopkins. The author has devised a simple device for rapidly dissolving salts. J. E. G.

IN *The American Naturalist* for November, J. H. Comstock and J. D. Needham continue the series on 'The Wings of Insects,' with an interesting account of the development of wings containing a discussion of the origin of the tracheation of the wing. 'A Contribution to the Morphology of *Pennaria tiarella*' McCrady,

is furnished by Martin Smallwood, who also discusses the development of the Medusa and the origin of the sex cells. The Medusæ of *Pennaria* are considered to be in a degenerate condition. The 'Reversal of Cleavage in *Ancylus*' is described by Samuel J. Holmes, who considers that it has a special significance from the fact that the left-handedness of this genus has probably arisen independently of that of *Physa* and *Planorbis*. The 'Synopses of North American Invertebrates' is continued by C. H. Turner, who furnishes a 'key to the Fresh-Water *Ostracoda*.' In the Reviews of Recent Literature, zoology claims an unusually large share.

THE *Journal of the Boston Society of Medical Sciences* commences its fourth volume with the October number. Under the title 'Recent Additions to the Warren Museum of the Harvard Medical School,' Thomas Dwight describes briefly a series of interesting abnormal human backbones. G. Hay discusses 'A Curious Relation between the Positions, as given by Dr. Weiland, of two Linear After-Images, studied in connection with the Law of Listing, and the Corresponding Angles of two Pairs of Great Circle Planes, as given by Helmholtz.' J. H. Wright contributes three beautiful plates showing a number of 'Photographs of Malarial Parasites.'

SOCIETIES AND ACADEMIES.

THE NEW YORK SECTION OF THE AMERICAN CHEMICAL SOCIETY.

THE October meeting of the New York Section of the American Chemical Society was held on Friday evening, October 6th, at the Chemists' Club, 108 West 55th Street.

The following papers were read:

'Some Notes on the Year's Progress in Applied Chemistry,' by William McMurtrie.

'Filters for Purifying Public Water Supplies,' by Allen Hazen.

'The Mordanting and Dyeing of Silk,' by Rafael Granja.

Robert Wilhelm Eberhard Bunsen, In Memoriam. A Tribute from former Pupils.

Dr. Doremus asked for original papers for presentation at the conference to be held in Paris next August.

The question of holding an extra meeting in November was discussed, but no final action taken. E. E. SMITH, *Sec'y Pro. Tem.*

THE regular meeting of the Section was held in the assembly room of the Chemists' Club, 108 West 55th Street, on Friday evening, November 10th. Sixty members were in attendance, Dr. C. T. McKenna presiding. The following papers were read:

1. Wm. McMurtrie, 'Some Notes on the Year's Progress in Applied Chemistry.'
2. M. Trubek, 'The Technical Analysis of Licorice Paste.'
3. P. A. Levene, 'On the Chemistry of Mucin.'

Dr. McMurtrie's continuation of his paper on the year's progress in applied chemistry was full of valuable material, and covered a wide range of subjects, among them the electrolytic production of alkali, the production of ozone on a large scale for bleaching oils and purification of water, improved shorter methods for manufacture of white lead, and a very full comparison of the efficiency of different gases and gas burners, as well as recent experimental work on the cause of light in the Welshbach mantle, and the best mixtures for the purpose.

It is expected that this paper will be published in full.

The question of a joint meeting with the Philadelphia Section was brought up by the Chairman, who stated that it had been decided to postpone the proposed meeting until after the holidays. DURAND WOODMAN, *Secretary.*

THE WASHINGTON BOTANICAL CLUB.

THE tenth regular meeting of the Club was held at the residence of Mr. C. L. Shear, October 4, 1899. The evening was devoted to informal accounts of the season's work in the field. Mr. Shear described his investigations on the coast of Oregon and Washington, where he was engaged more particularly in studying the sand-binders. *Carex macrocephala*, *Poa macrantha*, and *Elymus arenarius*, he stated, were the best examples of this class of plants in that region. Mr. Pieters spoke of the peculiar conditions of plant growth in the lake di-trict of Central Florida, each variety of soil yielding a different

class of species. Mr. Pollard briefly described a short collecting trip in West Virginia and Virginia.

THE eleventh regular meeting was held at the residence of Mr. C. L. Pollard, November 1, 1899. The election to active membership of Mr. William R. Maxon, of the United States National Museum, was announced. Mr. C. L. Shear spoke of his discovery of a truffle, *Terfezia oligosperma*, in Maryland, stating that this was the first record of its appearance in the United States. His remarks were illustrated by specimens and by microscope slides. Mr. J. N. Rose described the mescal industry of Mexico, exhibiting photographs of the mescal plant itself and of the mode of preparing the liquor, a sample of which was passed around among the members. Mr. L. H. Dewey gave an account of various weeds observed by him on a trip through the southern states during the past summer; the most prevalent species, he considered, were the following: *Leptilon divaricatum*, *Diodia teres*, *Cassia occidentalis*, *C. Tora*, *Helenium tenuifolium*, *Croton capitatus*, and *Solanum rostratum*. Mr. Pollard exhibited the first decade of a distribution of North American Violaceæ undertaken by Professor Greene and himself. Professor John M. Coulter, of the University of Chicago, who was present as a guest of the Club, gave a short address on the organization and aims of the department of botany in that institution.

CHARLES L. POLLARD,
Secretary.

DISCUSSION AND CORRESPONDENCE.

THE SCIENCE OF METEOROLOGY.

TO THE EDITOR OF SCIENCE: In reading the admirable address by Dr. Marcus Benjamin, in your JOURNAL of November 3d, it occurs to me that the learned Doctor is rather hard on meteorology when he speaks of "*that science which we now dignify by the name of meteorology*" (see page 628). Are we to understand that this science has recently been dignified by giving it this new baptismal name? Have we of the present generation devised this dignified name for a new branch of science? My understanding is that meteorology as a branch of philosophical study is quite as old as astronomy, if not older, and that the name 'meteorologia' originated with that profound school of philosophy of which Plato and Socrates were the expounders. To them, or possibly even to their predecessors, we owe the system of nomenclature 'astronomia,' 'meteorologia,' 'geometria,' etc., by which they designated the various branches of knowledge. Doubtless, Dr. Benjamin meant to refer to 'that science which Plato and Socrates dignified by the name of meteorology.' The correction is worth making in order that your readers may not forget that the study of the atmosphere has from the most ancient times been recognized as a distinct branch of science.

C. A.

NOTES IN PHYSICS.

THE MAGNETIZATION OF LONG IRON BARS.

DR. C. G. LAMB, in the *Philosophical Magazine* for September, gives some interesting experimental results concerning the distribution of magnetic induction along a long cylindrical iron rod. When the rod is weakly magnetized, the mean positions of its poles are comparatively near the ends of the rod; with stronger magnetization the poles move farther from the ends; and with very strong magnetization the poles move more and more towards the ends. This result, as Dr. Lamb points out, has important bearing upon the magnetic testing of iron by Ewing's method.

THE VELOCITY OF THE CHARGED AIR PARTICLES NEAR A DISCHARGING METAL POINT.

PROFESSOR A. P. CHATTOCK in the *Philosophical Magazine* for November, gives the results of a very ingenious determination of the velocity of the charged air particles or *ions* in the electrical discharge from a metal point. He finds the velocity to be 413 centimeters per second for positive ions, and 540 centimeters per second for negative ions, both for an electric field of 300 volts per centimeter. This result is in remarkable agreement with the velocities of the air ions which are produced by X-rays and by uranium radiations. Professor Chattock also shows that the velocity of the wind which blows from a discharging point is not greater than 2 per cent. of the velocity of the ions, and

he estimates that these ions are molecular aggregates of about 8000 ordinary molecules each. This estimate of the mass of the ions is, of course, based upon data not altogether satisfactory.

THE RESPIRATION CALORIMETER AT MIDDLETOWN, CONN.

PROFESSORS ATWATER AND ROSA give, in the *Physical Review* for September and October, a very complete description of the calorimeter chamber which they are using at Middletown in their interesting experiments upon energy transformations in the human body.

THE COMPENSATED ALTERNATOR.

THE alternating current dynamo, when used to supply current to lamps only, or to one type of electric motors only, may be made to give constant electromotive force by providing a compound field winding. When, however, an alternator supplies current in varying amounts to lamps and to motors simultaneously, the electromotive force cannot be kept constant by compounding. One of the most interesting of recent improvements in the alternator is that of E. W. Rice, Jr., of the General Electric Company. The alternator and exciter are mounted on the same shaft, and the alternating currents pass through the exciter armature on their way to the mains, causing such variations of the electromotive force of the exciter as to compensate for all kinds of variations of load on the alternator. This new alternator is described in the *American Electrician* for November.

W. S. F.

NOTES ON INORGANIC CHEMISTRY.

A PAPER has been lately issued by the Wisconsin Academy on the influence of the presence of pure metals upon plants, by E. B. Copeland and L. Kahlenberg. It is a complete refutation of the theory of Nageli of the oligodynamic effects of metals upon plants, which is that where a plant is growing in water, in contact with a metal as copper, a trace of copper goes into the solution as a metal and produces a toxic action very different from that produced by a salt of copper in solution. In the experimental portion of the work of Copeland and Kahlenberg, plants (corn, oats, lupines and soja beans) were grown in water in paraffin coated glass beakers, in which were exposed as nearly as possible the same surfaces of different metals. Twenty-five or more elements were tested, and while at the end of the experiment many of them were scarcely tarnished, most showed themselves to have had some influence upon the plant used. Comparing with the sequence given by Neumann of elements arranged according to their surface tensions—magnesium, aluminum, manganese, zinc, cadmium, thallium, iron, cobalt, nickel, lead, hydrogen, bismuth, arsenic, antimony, tin, copper, mercury, silver, palladium, platinum, gold—all of these elements down to mercury, except aluminum, tin and magnesium, are injurious, and excepting further manganese and bismuth, fatal during the time of the experiment. Mercury and silver were sometimes injurious, palladium, platinum and gold never. Regarding aluminum and magnesium, their salts are comparatively harmless. Comparing their results with the known toxicity of the salts of the corresponding metals, the authors conclude that the poisonous action is due to the solution of the metal in the form of a salt and not to an action of any other nature. The paper gives an interesting summary of our knowledge on the toxicity of metals toward plants, and has also a bibliography of the subject.

IN a paper on the heat of combination of copper with zinc, presented to the Chemical Society (London), Dr. T. J. Baker makes use of chlorin water and of HNO_3, $3H_2O$ as solvents of the brass. Up to 30% copper no heat of formation could be detected ; it then begins and rises to an ill-defined maximum at 62% copper, and then gradually sinks to zero at 100% copper. This alloy of 62% copper, while possessed of somewhat remarkable properties, does not correspond to any simple atomic compound (Cu_5Zn_3 = 61.8% copper) ; the existence of the supposed compound $CuZn_2$(= 32.6% copper) is rendered doubtful from the fact that the alloy of this proportion shows almost no heat of formation.

FURTHER researches on radiant matter in pitch-blende have been made by A. DeBierne,

and are published in the *Comptes Rendus*. Polonium, already found by Curie, seems akin to bismuth and radium to barium. DeBierne has worked upon that portion of the solution of pitch-blende which is not precipitated by hydrogen sulfid in acid solution, but is by ammonia or ammonium sulfid. In this portion were present with iron and aluminum small quantities of many other metals, as zinc, manganese, chromium, vanadium, etc., and rare earths. A new radiant substance was found closely akin analytically to titanium, whose power is 5000 times as great as that of uranium, but is not spontaneously luminous as in the case with radium.

IN the *Zeitung für Biologie* H. Harms has gone over again the question of the quantity of fluorin in bones, and his conclusion is that the amount varies from 0.005% to 0.022%, and that the quantity is so small and variable that it must be considered, not as belonging to the constitution of the bones and teeth, but as merely accessory.

IT has long been believed that the step from the inorganic carbon dioxid and water to organic plant substance, that is to the carbo-hydrates, was by way of formaldehyde, but the actual existence of the intermediate product could not be proven. By macerating fresh leaves with pure water and immediately distilling, it has been possible for Gino Pollacci to detect formaldehyde in the distillate. The test used for formaldehyde is the violet color given with codein and concentrated sulfuric acid.

A NOTABLE contribution to the stereo-chemistry of nitrogen by W. J. Pope and S. J. Peachey appears in the last Proceedings of the Chemical Society (London). When α-benzyl-phenyl-allyl-ethyl ammonium iodid is heated with silver dextro-camphorsulfonate, it is resolved into optical isomers, respectively dextro- and levo-rotary. Here the optical activity appears to be clearly due to the asymmetry of the quinquevalent nitrogen atom, linked to five different groups (or atoms). When the paper was read, Dr. Armstrong characterized it as being the most valuable contribution to stereochemistry since the introduction of geometrical considerations by Le Bel and van't Hoff. J. L. H.

SCIENTIFIC NOTES AND NEWS.

MEMORIAL exercises in honor of the late Edward Orton were held at the Ohio State University on November 26th. Addresses were made by President T. C. Mendenhall, Dr. G. K. Gilbert, Hon. T. J. Godfrey, Professor W. H. Scott and Professor S. C. Derby.

THE bacteriologists of America are planning to organize a society to meet during Christmas week in affiliation with the American Society of Naturalists. The first meeting for organization will be held at New Haven during the coming holidays. A program of papers has, however, been provided, and all interested in bacteriological topics are invited to attend. Information in regard to the Society may be obtained by addressing Professor H. W. Conn, Middletown, Ct.

DR. WILLIAM R. BROOKS, director of Smith Observatory, has just been awarded by the Paris Academy of Sciences 'the Grand Lalande' prize for his numerous and brilliant astronomical discoveries.

PROFESSOR CHARLES R. CROSS of the Massachusetts Institute of Technology will give a series of Lowell lectures on 'The Telephone,' beginning on December 19th.

A DINNER given by the Physical Society, London, was held at the Hotel Cecil on November 17th. The president of the Society, Professor O. J. Lodge, took the chair, and the guests included Right Hon. A. J. Balfour, Mr. G. Wyndham, M.P., Sir W. H. Preece, Major-General E. R. Festing, Dr. J. H. Gladstone, Professor A. W. Rücker, and Professors G. F. Fitzgerald, A. W. Reinhold, A. W. Ayrton, S. P. Thompson, G. C. Foster, and W. Ramsey.

A TOTEMIC column from southern Alaska has been presented to the museum of the University of Michigan by Leon J. Cole, assistant in zoology, who visited Alaska last summer as a member of the Harriman Alaska Expedition. The column is about ten feet high and three feet wide and is made from a tree trunk split lengthwise. It was taken by Mr. Cole from the interior of a house in a deserted village of the Tlingit Indians near Cape Fox.

DR. HENRY HICKS, F.R.S., died, near London, on November 18th aged sixty-two years. His father was a surgeon and he was himself a physician, being a specialist in mental diseases. He was, however, best known as a geologist, having contributed many important papers on geology and paleontology. He was secretary of the Geological Society from 1890 to 1893, and president from 1896 to 1898.

PROFESSOR JOHANN CARL WILHELM FERDINAND TIEMANN died of heart disease at Meran on November 13th, aged fifty-one years. He became a Ph.D. of Göttingen in 1870, and in 1882 was appointed professor of chemistry in Berlin University, undertaking from the same date the editorship of the proceedings of the German Chemical Society. Professor Tiemann was the author of numerous important researches having for their object the discovery of the constitution of the camphors, the terpenes, and other organic bodies. As a result of his work in theoretical chemistry, the manufacture of artificial flavoring matters and perfumes resulted, which is now an important German industry. Professor Tiemann was a brother-in-law of the eminent chemist A. W. von Hofmann.

THE death of Dr. Camara Pestana at Lisbon on November 15th, adds, says the London *Times*, another distinguished name to the list of martyrs to science. He caught the plague while studying the disease at Oporto. Dr. Pestana was chief of the Bacteriological Institute at Lisbon, a man in the prime of life, an ardent and most accomplished bacteriologist. It was his verdict on specimens sent him from Oporto for examination that conclusively established the existence of the plague there in August last. He paid several visits to Oporto to study the outbreak, and was present there when the foreign representatives of science visited the city. His courtesy and amiability greatly endeared him to all his colleagues, while his scientific attainments commanded their respect. His contributions to bacteriology, being written in Portuguese, are but little known, and the foreign bacteriologists visiting Oporto only then became acquainted with them for the first time. They were not less surprised than delighted with the originality and brilliancy of Dr. Pestana's work, and several of them expressed the opinion that if he had used a different language he would undoubtedly have enjoyed the European reputation which his researches deserved. He will be deeply and sincerely regretted.

SIR RAWSON WILLIAM RAWSON, died, in London, on November 20th in his 88th year. He was formerly vice-president of the board of trade and Governor of Barbados, but was interested in scientific matters, having been a member of the council of the Geographical and Statistical Societies, and president of the latter. He was the first president of the International Statistical Society established in 1885, and held this office for ten years.

THE death is announced of Mr. William Pamplin at the advanced age of ninety-two years. He was elected an associate of the Linnæan Society in 1830, and made various contributions on the geographical distribution of British plants.

THE death is also announced of Professor Spirgalis, for thirty years director of the laboratory of pharmaceutical chemistry at Königsberg.

A COLOSSAL bronze statue in honor of Ferdinand de Lesseps was unveiled at Port Said on November 17th. Among the addresses was one by Vicomte Melchior de Vogüé, representing the French Academy, who testified to de Lesseps's services to art and science and especially to his indomitable energy.

THE Parliament of Queensland has voted £1,000 towards the funds of the British Antarctic expedition.

THE American Society of Mechanical Engineers is holding its meeting in New York during the present week.

THE third International Congress of Photography is to be held in Paris from July 23 to July 28, 1900. The General Secretary is M. S. Pector, 9 Rue Lincoln, Paris.

IN accordance with the policy of the War Department for a systematic collection of as many interesting relics from Cuba, Puerto Rico and the Philippines as possible for exhibition in

Washington, Major General Brooke, commanding the division of Cuba, has issued the following circular to the officers serving on that Island:

"Officers of the army serving in Cuba are requested to procure wherever practicable any object of historical, ethnological or artistic interest that it may be possible for them to obtain in a proper manner for shipment by government transports, to be deposited among the government collections in the Smithsonian Institution at Washington."

THE Indian correspondent of the *British Medical Journal* reports that the Muktesar Bacteriological Laboratory, including the residence of the Imperial Bacteriologist, which formed part of it, has been completely gutted by fire. Owing to the large amount of pinewood which had been used in the construction of the building, including an enclosed wooden veranda on either side, the flames, which broke out at night, aided by a strong wind, spread with such rapidity that much of the laboratory apparatus, and nearly all private property, was lost. It is stated, however, that the whole of the records of the rinderpest experiments which have been carried out throughout the present year, together with efficient apparatus to allow of their being continued, and all the Government library, have been saved. Surgeon-General Harvey will visit Muktesar early in November, when it is expected that arrangements will be made for the reconstruction of the building, as the walls are reported to be sound.

UNIVERSITY AND EDUCATIONAL NEWS.

THE University of Pennsylvania has received a gift of $250,000 for the construction and equipment of a laboratory of physics, which will be erected at Thirty-fourth and Locust streets. The name of the donor is withheld for the present.

IT was announced in this JOURNAL last week that funds had been provided for a chair of geology in McGill University in memory of the late Sir William Dawson, the income to be given to Lady Dawson during her life. At the last meeting of the Governors of the University, it was announced that the donor is Sir William MacDonald, to whom the University is already indebted for such great gifts. The amount of the endowment is $62,000 and the chair is to be known as the Dawson chair of geology. There is already a Logan chair of geology in the University, filled by Professor Frank D. Adams, but a second will be filled when the income becomes available.

WESLEYAN UNIVERSITY has received a gift of $38,000 from Miss Elizabeth A. Mead, subject to an annuity during her lifetime. St. Lawrence University has received $34,000 from various sources. North Western University has received $15,000 from Dr. R. D. Sheppard toward the cost of a gymnasium.

HON. WM. C. TODD, of Atkinson, N. H., the founder of the newspaper reading room of the Boston public library, has just made the gift of $500 to the library of Washington and Lee University, to be used chiefly for books on chemistry.

IT is probable that a college for teachers will be established at Cornell University with the aid of funds from New York State. By the increase in the number of the assembly districts in the State, Cornell University must educate eighty-eight additional students without charge, and it is reported that President Schurman and the Superintendent of Public Instruction have asked for support for the college for teachers in return for these scholarships. The College will be on the same basis as the State Veterinary College and the State College of Forestry, in which the cost of professional training is provided by the State, and the other instruction by the University.

A UNIVERSITY Council has been established at Yale University, the function of which is specially to consider questions which concern more than one school or department. The first members are Dean Wright and Professors Dana, Perrin and Sumner of the academic department; Dean Chittenden and Professors Lounsbury and Pirsson of the Scientific School; Dean Phillips of the Graduate School; Dean Wayland and Professor S. E. Baldwin of the Law School; Dean Smith and Professor Carmalt of the Medical School; Dean Fisher and Professor Brastow of the Divinity School; Dean Weir of the Art School, and either Professor Parker or Professor Sanford of the musical department.